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THE FRANKLIN INSTITUTE.

The Development of the American Locomotive.

(Being the report of the Committee on Science and the Arts on the Contribution of the Baldwin Locomotive Works. Sub-Committee: Charles E. Ronaldson, Chairman; T. Carpenter Smith, Arthur Falkenau, Strickland L. Kneass.)

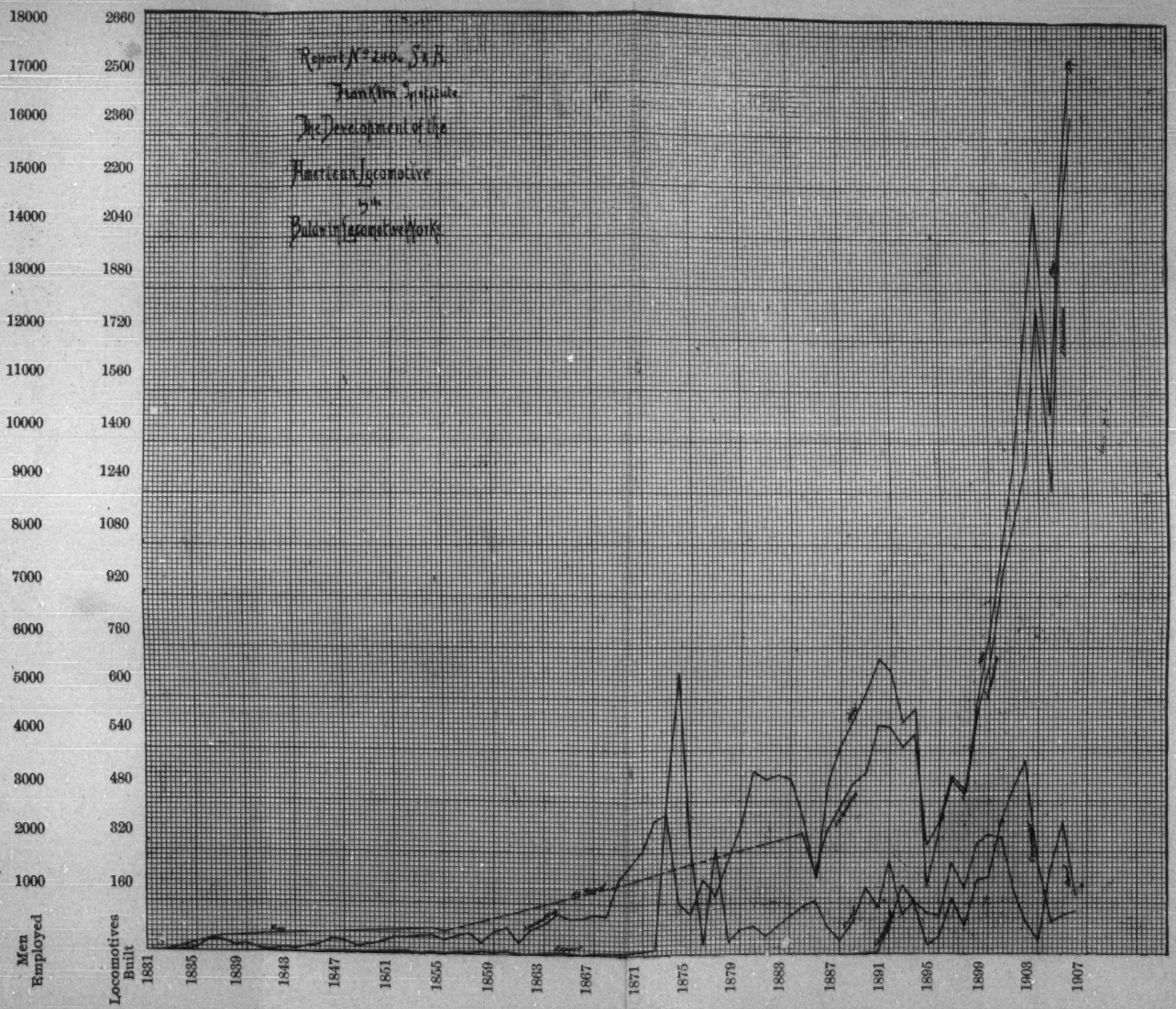
(No. 2405)

The Franklin Institute, acting through its Committee on Science and the Arts, investigating the "Development of the American Locomotive," as exemplified in the Baldwin Locomotive Works, of Philadelphia, reports as follows:

The most striking example of a purely Philadelphia institution, in which her citizens take a just patriotic pride and which stands pre-eminently typical of careful systematic management is the venerable and justly renowned Baldwin Locomotive Works.

Founded in 1831, in an extremely modest way, they have forged ahead (though encountering many vicissitudes and set-backs) until to-day they are foremost, commanding the respect and admiration of the world.

From their first locomotive, which consumed over a year to complete, they are to-day turning out nearly fifty-two completed engines every week, while it is fair to presume that even this


Report No. 240. J.F.I.
Franklin Institute.
The Development of the
American Locomotive
by the
Baldwin Locomotive Works.
Men Employed
Locomotives Built
18000
17000
16000
15000
14000
13000
12000
11000
10000
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great number may increase in the near future. The problems of maintenance, production and management, intricate and perplexing, have all been satisfactorily solved, and to-day these vast works operate systematically and smoothly without apparent friction of any sort whatever.

During the seventy-five years and over of their existence, they have kept abreast of the rapidly increasing requirements of the railroads throughout the civilized world, while in later years when the demand for electrical engines developed we find these works turning out a product second to none; and when the compound locomotive came into vogue, these works were quick to take hold of and produce their own type of this class of engine.

In the process of evolution from the first crudely constructed locomotive, the American type developed, having four driving wheels and a four-wheeled truck; then followed the ten-wheeler; then the "Mogul," "Consolidation," "Mastodon," "Decapod," "Atlantic," "Mikado," "Prairie," "Pacific," and "Santa Fe" types, besides a great variety of locomotives of different gauges and for different kinds of service, representing current requirements.

The Letters Patent owned and controlled by this company are "legion" in point of numbers, so that it is imposisble to enumerate all of them, the Committee confining themselves to those that were esesntial to the efficiency of the American Locomotive as exemplified to-day.

A distinguishing feature which characterizezs the means for securing absolute uniformity of the essential detail parts of all locomotives of the same class, is the use of standard gauges and templates, which has resulted in the formation of the "Department of Standard Gauges," which is looked after by a special foreman and an adequate force of skilled workmen, it being recognized many years ago that like parts of similar engines should be absolutely uniform and interchangeable, which results in insuring to the purchaser a minimum cost for repairs and rendering possible by this method the extraordinarily increasing output of these works. This department contains standard gauges and templates of every description of work to be done. The original templates are kept as "Standards," and are never used upon any work itself, and from them exact duplicates are made and used and to which all work is required to conform. The working

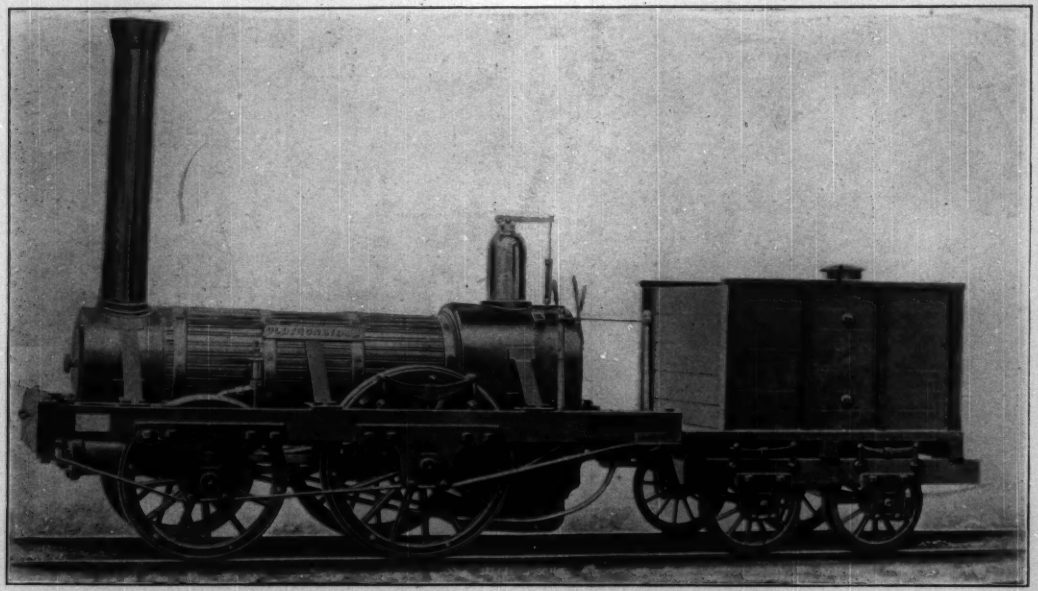


Fig. 0.—"Old Ironsides."

gauges are compared to the "Standards" at regular intervals, thus maintaining absolute uniformity for every possible important detail of construction.

Matthias W. Baldwin was born in Elizabeth, N. J., on December 10, 1795. He was elected Vice-President of the Franklin Institute in 1855. He learned the trade of a jeweler, and was in the service of Fletcher & Gardiner, silversmiths and jewelers, until about 1819, when he began business for himself, opening a small shop upon similar lines. In 1825 he formed a partnership with David Mason, a machinest, manufacturing bookbinders' tools and cylinders for calico printing. Their business prospered, steam power became necessary; the engine they bought proving unsatisfactory, Mr. Baldwin designed and built an engine suitable to their requirements, which in a short while proved so efficient that he received orders for additional ones. This original "upright" stationary engine, built prior to 1830, is still in good order and carefully preserved at the works. Thus, Mr. Baldwin became interested in the manufacture of stationary engines. Steam as a motive power on railroads engaged the attention of American engineers in 1829-30; a few locomotives having been imported from England, and one was built at the West Point Foundry, in New York. In 1831, Mr. Baldwin completed a miniature locomotive, for Mr. Franklin Peale, for exhibition in his museum. The success of the model was such that Mr. Baldwin received his first order for a locomotive from the Philadelphia, Germantown & Norristown Railroad Co. In those early days it was almost a superhuman task to undertake such a work. Mechanics were very few; suitable tools could hardly be obtained, cylinders had to be bored with a chisel fastened in a block of wood, while blacksmiths who could weld bars of iron exceeding 1¼ inches square were exceedingly few, or not to be had. Therefore, Mr. Baldwin had to do most of the work himself in order to educate the men who assisted him to fashion the necessary tools for the various processes. The work was prosecuted notwithstanding and the locomotive completed and tried on November 23, 1832. This was the famous "Old Ironsides." Thirty men were employed at this time.

In the second locomotive built the valve motion was actuated by a fixed eccentric for each cylinder, the straps of each had two arms attached, one above, one below, the driving axle being back

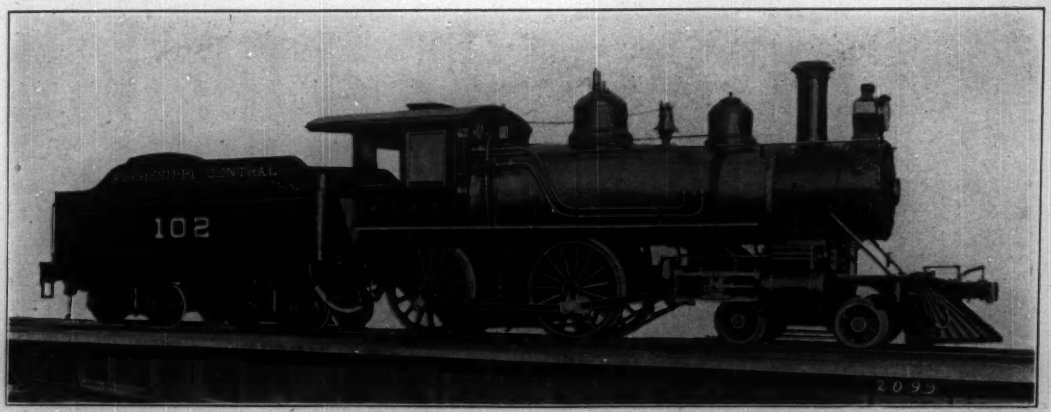


Fig. 1.—"American Type."

of the fire-box, these arms were prolonged backwards under the footboard, with a hook upon the inner side of the end of each; the rock-shaft had arms above and below its axis and the hooks of the two rods were moved by hand-levers, to engage with either arm, thus producing forward or the reverse motion. In 1834, five locomotives were completed, and the shop becoming too small for the increasing business, a new shop was erected at Broad and Hamilton Streets, and the business removed to it in 1835. The important devices adopted and employed in these early engines, being the result of Mr. Baldwin's study and experiments, were patented in 1834, and the same patent covering the following inventions, viz.:

1. The Half Crank.
2. New Method of Constructing Wheels for Locomotives and Cars.
3. New Mode of Forming Joints of Steam and other Tubes.
4. New Mode of Forming Joints and other parts of the Supply Pumps and of Locating the Pump Itself.

This last claim consisted in utilizing the hollow guide bar and making it do duty as the pump-barrel, the plunger of which was attached to the piston rod. Mr. Baldwin laid great stress upon the position of the driving wheels by placing them back of the fire box; thus throwing one-half the weight upon them and one-half upon the four-wheeled truck, thus extending the wheel base and producing steadiness and less track damage.

The application of ground steam joints in the steam pipes added greatly to the success of his early engines, and this manner of grinding the joints is now universally used. In 1839, Mr. Baldwin bought the E. L. Miller patent, this being a method of increasing the adhesion of the locomotive by throwing the weight of a part of the tender upon the rear of the engine.

In the early part of 1835, the new Broad Street shop was completed and occupied. On April 3, 1835, Mr. Baldwin took out a patent for certain improvements in the wheels and tubes of locomotives. That for the wheel related to casting the hub and spokes together and having the spokes terminate in segments of a rim. The improvements in tubes consisted in driving a copper ferrule or thimble upon the outside end of the tube. The object was to make a tight joint with the tube sheet and the advantage gained by the outside ferrule strengthened the

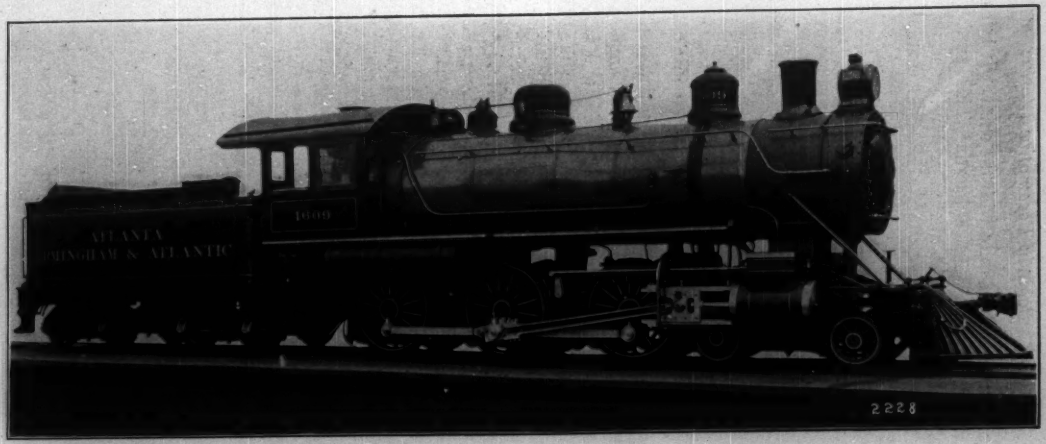


Fig. 2.—"Ten-Wheel Type."

tube and made a tight joint with the sheet. It left the tube free and unobstructed its entire length. This patent proved extremely valuable, and the method is now generally used.

In this year the first outside-connected locomotive was built, and it embodied the Miller device and was put in service upon the Philadelphia & Trenton Railroad.

In 1835, 14 engines were constructed.
" 1836, 40 " " "
" 1837, 40 " " "
" 1838, 23 " " "
" 1839, 26 " " "
" 1840, 9 " " "

and 300 men were employed.

The average weight of these locomotives was between 20,000 and 26,000 pounds. The number of men employed was 300, yet this force was reduced weekly, the demand for engines rapidly falling off in 1838, as will be seen from the above table of annual production.

In the latter part of 1839, the old wooden frame disappeared, the machinery truck and pedestals of the driving boxes were attached to an iron frame which took its place, and we find that eight-wheel tenders were first being used about this time.

In 1842, Mr. Baldwin secured a patent for his flexible truck, which contributed more than any of his subsequent patents or inventions to the foundation of his fortune, and led to the construction of his well-known six-wheel connected locomotive, which had the four front drivers combined in a flexible truck: the rear wheels were rigidly placed in the frame, behind the fire box, with inside bearings. The action of the flexible beam was such that the engine in passing a curve the middle pair of drivers could move laterally in one direction, say to the right, while the front pair would swing in the opposite direction, or, to the left, the two axles remaining parallel to each other and to the rear driving axle. The operation resembled that of a parallel ruler; on a tangent the axles and beams formed a rectangle, on a curve, a parallelogram. We call attention to this flexible truck patent, as it was fundamental to the future development and perfection of the Baldwin locomotive.

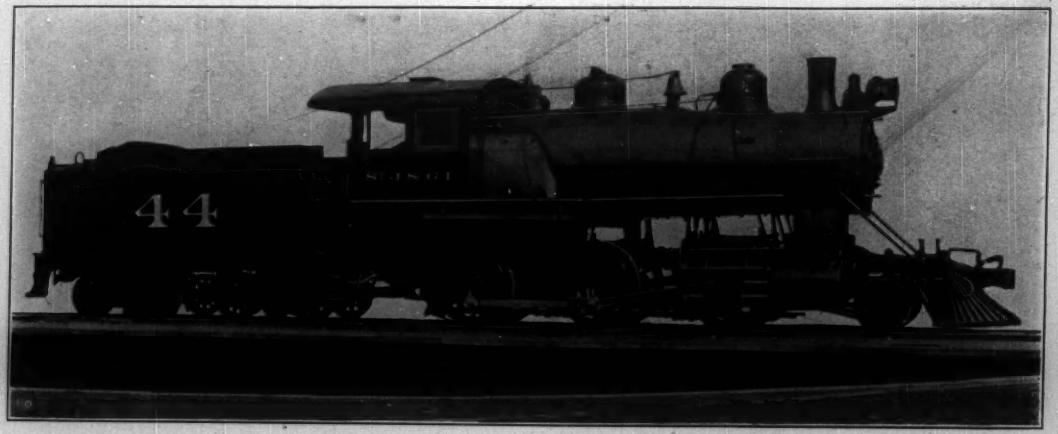


Fig. 3.—"Mogul Type."

In 1842, 14 locomotives were constructed.
" 1843, 12 " " "
" 1844, 22 " " "
" 1845, 27 " " "
" 1846, 42 " "
" 1847, 39 " " "
" 1848, 20 " " "
" 1849, 30 " " "
" 1850, 37 " " "
" 1851, 50 " " "
" 1852, 49 " " "
" 1853, 60 " " "
" 1854, 62 " " "

and 500 men were employed.

The performance of the first locomotive using the flexible truck excited widespread interest. The weight of the engine was but twelve tons, its haul was 250 tons, upon a grade of thirty-six feet per mile.

In 1842, the method was used of giving to each type of locomotive a distinct classification, composed of a number and a letter, besides systematizing many details in their management of the business.

Mr. Baldwin first used iron flues or tubes in 1844, and the advantage found was in the fact that the iron flue sheets and iron tubes expanded alike, while the unequal expansion of iron sheets and copper flues caused leakage. Link motion was first applied in 1845, and also the "half stroke cut off." The present design of four drivers and a four-wheeled truck was first adopted by Mr. Baldwin in 1845. In 1846, an eight-wheel connected type of engine was built, and at this time the wooden cab with sash and glass was added, and made for the Baltimore & Ohio Railroad. In 1847, rocking grate bars were introduced, and the first "rack" locomotive was built. In 1848, steel axles were first used. Fast-speed passenger locomotives were able to travel sixty miles an hour. In 1849, outside-connected engines were built almost exclusively. In 1850, the wagon-top boiler superceded the old dome boiler, which had been in use since 1834.

In 1852, the ten-wheel engine was placed in the Baldwin classification, yet not until 1860 did this type of engine wholly super-

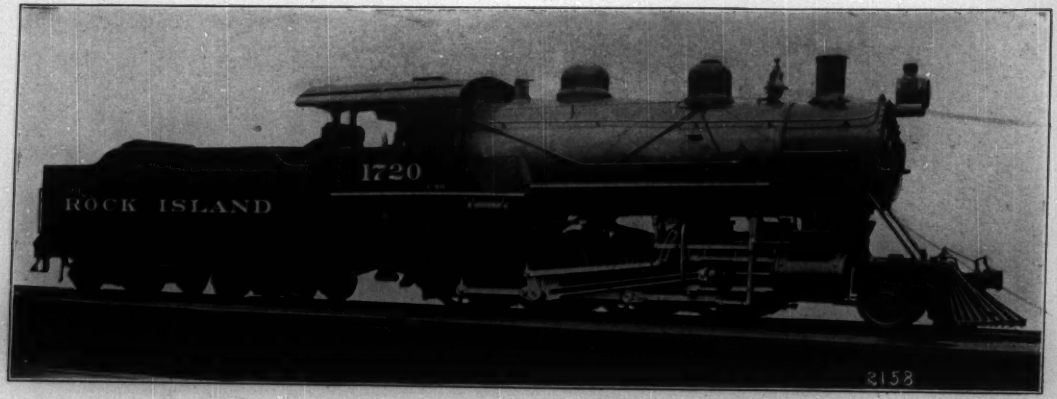


Fig. 4.—"Consolidation Type."

sede the old pattern of six-or eight-wheel connected. In this year, Mr. Baldwin patented his "variable cut off," which device never came into general use. Link motion, however, was generally introduced at this time and rapidly gained in favor, and in 1857, it was adopted exclusively. Fire brick arches in the fire box were used and adopted about this time, supported on side plugs. In 1858, water pipes extending obliquely from the crown down and curving to the sides of the fire box at the bottom were used.

The adoption of the link-motion clearly marks the dividing line between the early experimental and the present locomotive practice. Changes since then have been made, but in detail principally, yet it has been in the perfection of these details that we have to-day the efficient, symmetrical, complete piece of mechanism which stands out as one of the greatest tributes to the ingenuity of man. To-day, one can hardly realize the almost insurmountable difficulties which have been overcome to bring the locomotive to its high efficiency, and in perfecting all this the Baldwin Locomotive Works has had no small share in its success.

In 1855, 47 engines were completed.
" 1856, 59 " " "
" 1857, 66 " " "
" 1858, 33 " " "
" 1859, 70 " " "
" 1860, 83 " " "

and 430 men were employed.

The greater number of these locomotives were of the ordinary American type, four drivers, four-wheeled truck, varying in weight from fifteen to twenty-seven tons. A few ten-wheeled engines were built, the remainder being the flexible truck with six and eight-wheels connected. The demand for these was rapidly falling off, the ten-wheeled and heavy four-wheel connected and four-wheeled truck engines were taking their place, and by 1859, they ceased to be built, save in exceptional cases for export. Intense interest was taken at this time in the proper means to be employed in combustion. Various experiments were tried in the fire boxes. The result of study and experiment led Mr. Baldwin to the conclusion that the ordinary form of boiler, with plain fire box, was right, with, perhaps, the addition of the

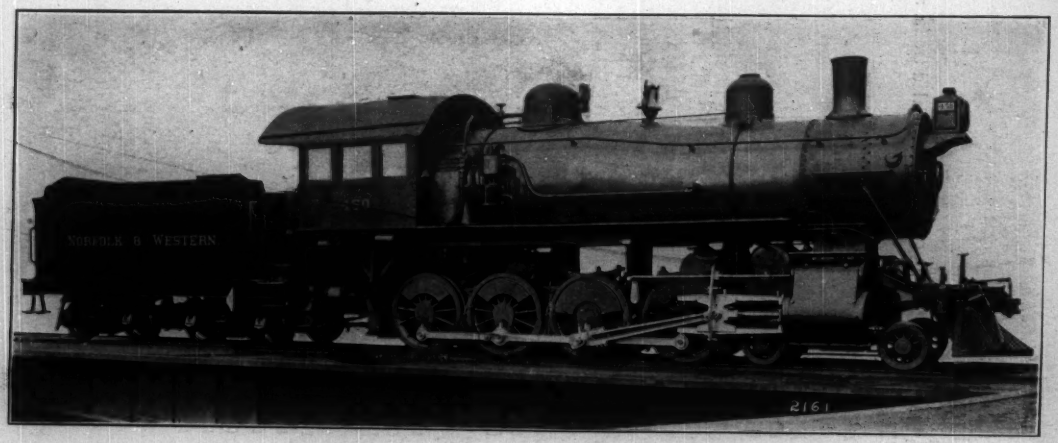


Fig. 5.—"Mastodon Type."

fire brick arch; that the secret of successful and economical use of coal was in the manner of firing, rather than in any particular design of fire box.

The breaking out of the Civil War unsettled trade, and a notable falling off in building occurred.

In	1861,	40	locomotives	were built.
"	1862,	75	"	" "
"	1863,	96	"	" "
"	1864,	130	"	" "
"	1865,	115	"	" "

In 1861, eighteen-inch cylinder freight locomotives with six wheels connected, with a pony-truck were built. This is the first instance of the use of the "Pony" truck in these works.

The introduction of steel in locomotive construction became a distinguishing feature at this time, and steel has gradually replaced wrought iron, etc., for tires, fire-boxes, and boilers. Another distinguishing feature at this time was placing the cylinders horizontal. Casting the cylinder and the half saddle in one piece, and fitting it to the circular smoke-box was designed by Mr. Baldwin. He was the first builder to adopt an outside cylinder, with a circular flanged segment cast to it, in order to be bolted to the boiler. The advantages of this arrangement are simplicity, strength and economy. The cylinders can be used for rights and lefts, one pattern answers for either. From high inclination the cylinders were gradually brought to less until the horizontal position was attained and maintains to-day.

In	1866,	118	locomotives	were built.
"	1867,	127	"	" "
"	1868,	124	"	" "
"	1869,	235	"	" "
"	1870,	280	"	" "
"	1871,	331	"	" "

In 1866, the "Consolidation" type came into use, the first engine being the "Consolidation," built for the Lehigh Valley Railroad Company. It had four pairs of drivers connected and a Bissell-Pony Truck. The following year (1867) the "Mogul" class of engine, with three pairs of drivers connected and a swinging pony-truck took its rise in the practice of these works

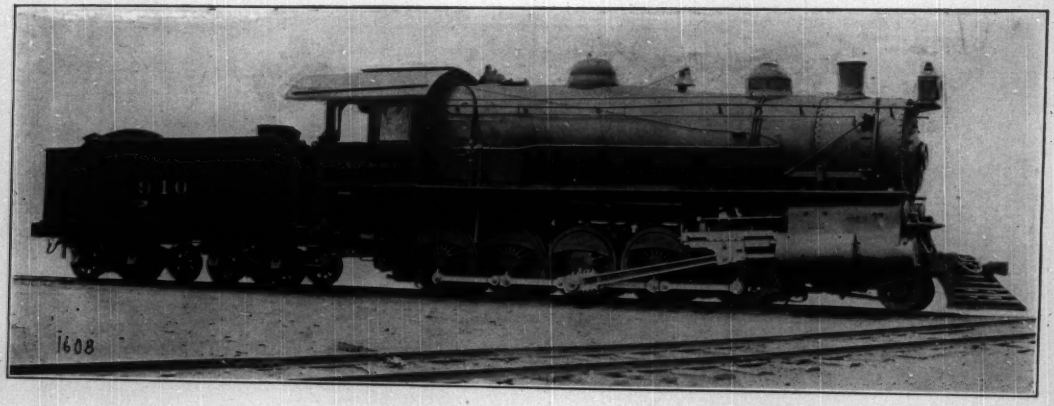


Fig. 5a.—"Decapod Type."

from the "E. A. Douglas," built for the Thomas Iron Company, and this plan of engine has rapidly grown in favor for freight duty upon grades and where heavy loads are to be carried.

Steel flues were first used in ten-wheel freight engines in 1868, and also steel boilers the same year. The 1854 type of engine having a straight boiler and two domes was revived in 1866, and until 1880 both the straight and wagon top boilers were built; yet since 1880 the two domes have been seldom specified. The first narrow gauge locomotive ($3\frac{1}{2}$ ft.) was built in 1868. The decade 1870-1880 witnessed the introduction of several improvements. In June, 1871, a double-ender locomotive was designed for suburban service on the Central Railroad of New Jersey. This was the first engine to have a truck with side bearings. These were used on the rear truck, which had four wheels.

In 1878, a locomotive driver brake, operated by steam, was introduced by these works. This brake was operated by a slide valve, which was replaced in 1882 by an improved form of disc valve. When required the brake was arranged for application to tender as well as driving-wheels. The equalized tender brake on both trucks was first used in 1872, by the Baldwin Locomotive Works. Locomotives for single-rail lines were built in 1878-79.

A locomotive for a gold mine in California was built in 1876, the gauge being but twenty inches. Steel tires were first shrunk on without being secured by bolts or rivets in any form in 1870, and now this is the prevailing custom.

In	1872,	422	locomotives	were built.
"	1873,	437	"	" "
"	1874,	162	"	" "
"	1875,	130	"	" "
"	1876,	232	"	" "

and nearly 3,000 men employed.

A small locomotive operated by compressed air was built in 1875. During the year 1876, a new departure in locomotive engineering in these works took place—an experimental steam street car was built, which, proving in a great massure a success, the next step was the construction of a "Motor" car, to which one or more ordinary cars could be attached. Steel fire boxes with

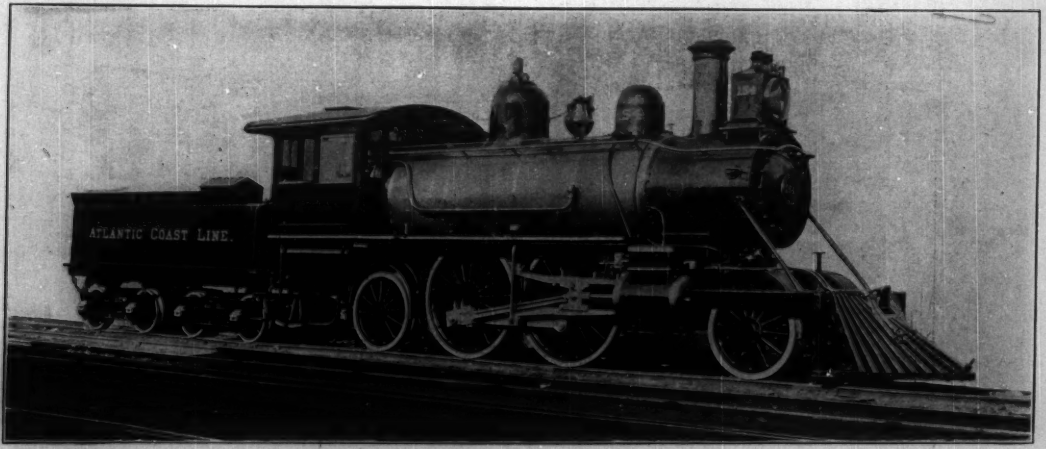


Fig. 6.—"Columbia Type."

vertical corrugations in the side sheets were first made by these works in 1876.

In 1885, the "Decapod" locomotive was built, having ten-wheels connected, with a "Pony" truck. A locomotive was constructed during the year 1886, having an outside frame. In 1887, a new form of boiler was built. An extended wagon-top was used, extending, to allow the dome to be placed in front of the fire-box, near the center of the boiler having the crown sheet supported by radial stays from the outside shell. Many boilers of this type have since been consructed. These works have also taken an active part in the development of the "Wootten" boiler, in its original and modified forms. They were the first to place the grate above the frames and thus use all the space between the wheels for the width of the fire-box. The first locomotive for Japan was shipped in June, 1887.

During 1888-89, an active demand sprung up for steam motors for street railway service, and ninety-five of them were built; also, two rack-rail locomotives of the "Riggenbach" system for foreign locomotive service were built.

In October, 1889, the first compound locomotive was completed. It was the four-cylinder type designed and patented by Mr. S. M. Vauclain, then the general superintendent of the works. That they came rapidly into use is evidenced by the fact that in the year 1889 one was built.

In	1890,	3	were built.
"	1891,	82	" "
"	1892,	213	" "
"	1893,	160	" "
"	1894,	30	" "
"	1895,	51	" "
"	1896,	173	" "
"	1897,	86	" "
"	1898,	235	" "
"	1899,	241	" "

Records show that the first cast-steel driving wheel centers were used in France in the year 1890. The Baldwin Locomotive Works began their use in 1891, and thus early availed themselves of this improvement.

In 1889, a test was made to see in how short a time a locomo-

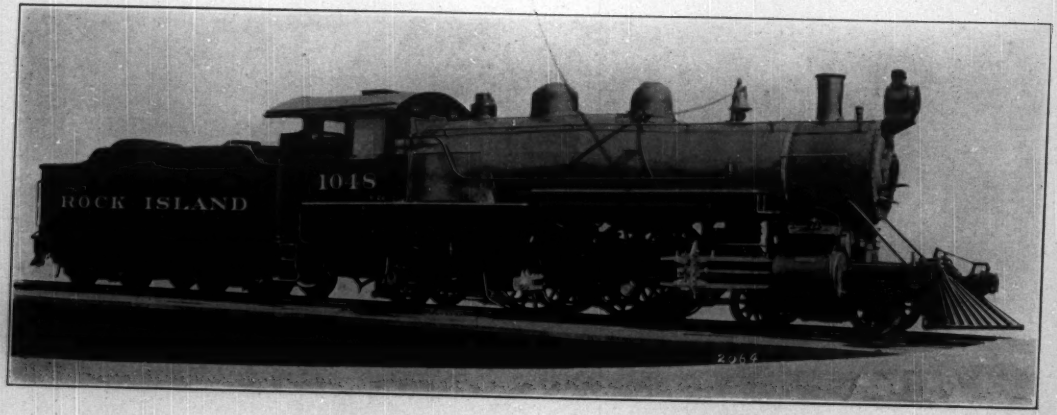


Fig. 7.—"Atlantic Type."

tive could be built. The order was given upon June 22nd, for a narrow gauge locomotive, "American" type, for passenger service and upon July 2nd it was completed, having consumed but eight working days from the raw material.

In this year, the manufacture of wrought iron wheel centers for both truck and driving wheels was begun, under patents of Mr. Vauclain.

In 1890, the first rack-rail locomotive under the "Abt" system was constructed for the Pike's Peak Railroad Company, and during this year and 1893, four locomotives of this type were built for this road, the grades varying from 8 to 25%.

Three "Mogul" type locomotives of one metre gauge were built and shipped to Palestine in 1890.

In 1891, the largest locomotives in the history of the works were designed and built for service in the tunnel under the St. Clair River, of the Grand Trunk Railway. They were ten-wheel connected with tanks on the boiler and weighed each, in working order, without fire, 186,800 lbs. Five compound locomotives of the "Decapod" pattern were built for the Erie Railroad.

The first locomotives for Africa they built this year. They were of the "Mogul" type, for 3 ft. 6 in. gauge.

In 1892, we find 731, and in 1893, 772 engines were constructed. Two rack-rail locomotives were built for a mountain road in Italy and twenty-five compound "Forney" locomotives for the South Side Elevated Railroad of Chicago. At the Columbian Exposition were exhibited seventeen locomotives, the product of the works, illustrating the various types of both "standard" and "narrow" gauge locomotives.

In 1892, a new design of high speed locomotive was produced by these works. This was the "Columbia" type, which had a two-wheeled leading truck, two pairs of driving wheels and a single pair of trailing wheels. A limited number of this type of engine was built for passenger service.

The depression in general business which set in in the summer of 1893 had a serious effect upon these works, and we find the number of engines completed in 1894 was 313. In 1895, a new type of passenger locomotive was brought out. To this the name "Atlantic" type was given. Its advantages are a large fire-box and boiler, enabling high speeds.

The first electric locomotive was built this year for the North

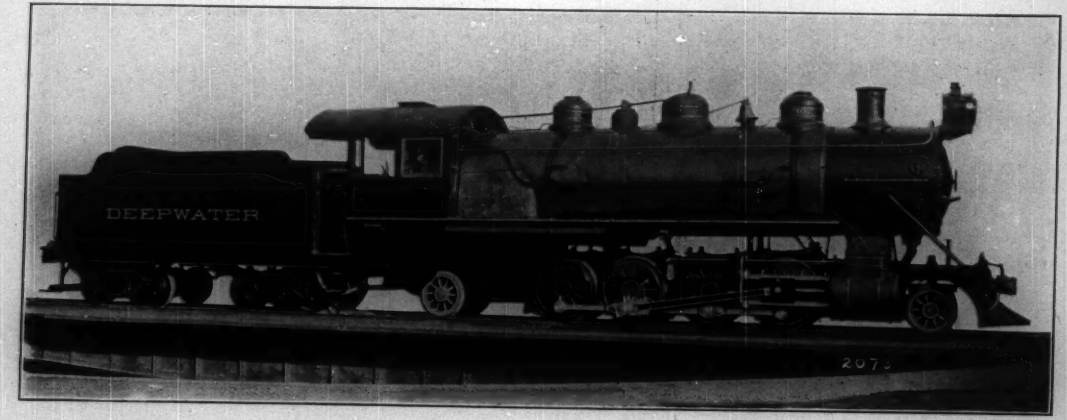


Fig. 8.—"Mikado Type."

American Company. Two other "Mine" electric locomotives were built in 1896 in cöoperation with the Westinghouse Electric and Manufacturing Company, they supplying the electrical parts.

A high-speed passenger locomotive was built for the Reading Railroad, having a single pair of drivers 84¼ inches in diameter. This engine and a duplicate built in 1896 were regularly used in hauling trains between Philadelphia and Jersey City, this distance being ninety miles. They accomplished this in 105 minutes, making six stops. A combination rack and adhesion locomotive was built for service in San Domingo. It was of the compound type, having the compound cylinders to operate two pairs of connected adhesion wheels and a pair of single expansion cylinders to operate a single rack-wheel, constructed upon the "Abt" system. This engine was furnished with two complete sets of machinery, entirely independent of each other, and was built eventually to remove the rack attachments and to operate by adhesion solely. During this year and in 1896, 138 locomotives of the four-cylinder compound type were sent to Russia.

In 1896, two combination rack and adhesion locomotives were sent to Mexico, having compound cylinders connected to the driving wheels through walking beams. Two pairs of wheels are secured to the axles by clutches and act as adhesion driving wheels and the rear wheels are loose on the axle and act only as carrying wheels. All three-coupled axles carry rack pinion of the "Abt" system.

Six ten-wheel locomotives were built for the Baltimore & Ohio Railroad for express passenger service, and have been operated with great efficiency.

In 1897, the Reading Railroad placed a fast express train in service between Camden and Atlantic City, N. J., 55½ miles, allowing 52 minutes for the run, equivalent to a speed of sixty-four miles per hour. The railroad records show that for fifty-two days, July 2nd to August 31st, 1897, the average time consumed was but forty-eight minutes, or a speed of sixty-nine miles per hour and once the train covered the distance in 46½ minutes or $71\frac{6}{10}$ miles per hour. These engines were of the "Atlantic" type, Vauclain Compound.

A new form of steam dome was patented and introduced in 1897. The dome base, or flange, was made of pressed steel, as was also the ring or top. The upper edge of the flange was in

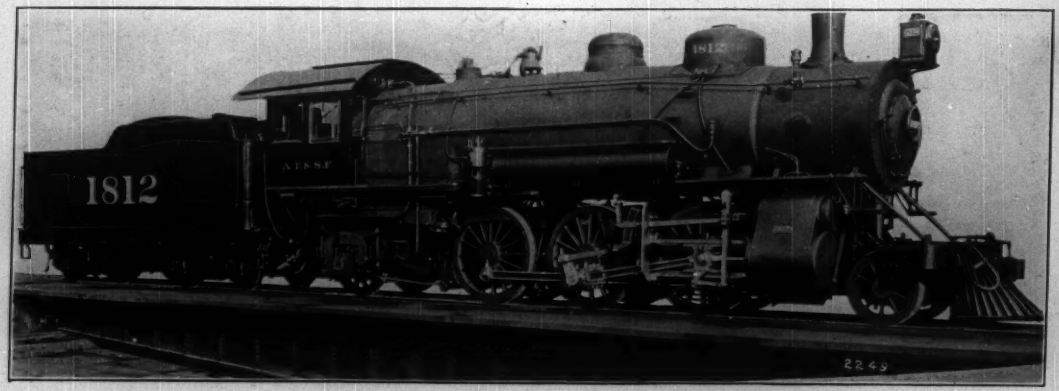


Fig. 9.—"Prairie Type."

one horizontal plane, so that the body, which was of boiler plate, was of uniform width throughout. The body was seamless, having a lap-welded joint. The interior of the flange was bored out to fit the body, which was shrunk over the ring, or top piece. The flange was radially planed to fit the boiler shell. This form of steam dome construction is universally used not only at the Baldwin Locomotive Works but in many other parts of the world. With the introduction of this form of steam dome, the practice was begun, at these works, of welding the longitudinal seam on the dome course. The seam was located on the top center line and was welded throughout its length on each side of the opening. This practice has become general on large boilers. A liner is frequently placed on the inside of the shell, to strengthen the joint.

In 1898, a "Consolidation" Vauclain Compound locomotive was placed in service upon the mountains between Coxton and Fairview, upon the Lehigh Valley Railroad. It was guaranteed to haul a load of 1000 net tons (exclusive of the weight of the engine and tender) upon a grade of sixty-six feet to the mile. It was so successful in the test that fourteen additional locomotives were subsequently ordered by this company.

In 1899, two "Atlantic" type Vauclain Compound locomotives were built for the Burlington Railroad, for fast mail service west of Chicago.

During this year there was a large increase in foreign business, including thirty locomotives for "Midland" and twenty for the "Great Northern" and twenty for "Great Central Railways of England," ten locomotives were ordered by the "French State" and ten by the Bone Guelma Railways, in the French Colonies of Algiers. Also, two Vauclain "Consolidation" freight locomotives for the Bavarian State Railways; and in 1900, this company ordered two passenger engines of the compound "Atlantic" type and embody in their passenger rolling stock the new features contained in these machines.

During 1900, these works exhibited at the Paris Exposition a "Goods" locomotive, "Mogul" type, for the Great Northern Railway of England; an "Atlantic" type pasenger locomotive for the French State Railways; also a compound "American" type passenger locomotive for this same road. These engines were built in the regular course of business for their respective companies

Fig. 10.—"Pacific Type."

and were put into service immediately after the close of the exhibition. The company filled large orders this year for the Chinese Eastern Railroad, the Paris-Orleans Railroad; the Finland State; the Egyptian State, and the Belgian State Railroads.

The incoming of the twentieth century witnessed an industrial "boom," and general prosperity throughout America, and in consequence entailed extraordinary demands for freight transportation. Cars were designed and built to carry heavier loads, resulting in improved road beds, heavier rails, stronger bridges, and more powerful locomotives. The demand for increased horsepower, involving greater steaming capacity and a larger grate area evolved the "Atlantic" type locomotive from the "American" type or eight-wheeled pasenger engine, so in order to produce a locomotive to cope with the enhanced condition, viz.: heavier trains at high speed, the "Prairie" type of engine was designed, a type resulting from the "Mogul" or ten-wheeled locomotive. This engine has a pony-truck, three pairs of driving wheels and a wide fire-box extending over the frames and placed back of the driving wheels. To support this overhanging weight a pair of trailing wheels is placed beneath the fire-box. Fifty of these locomotives were built for the "Burlington," and forty-five for the Atchison Railroads in 1901. A new departure in locomotive practice was exhibited by these works at the Pan-American Exhibition, at Buffalo, N. Y., in 1901, being a ten-wheel locomotive built for the Illinois Central Railroad, the fire-box and tender embodying the inventions of Mr. Cornelius Vanderbilt, M.E. The fire-box was cylindrical in form, its axis excentric to that of the boiler is riveted to the back head of the boiler and supported at the bottom by the man hole, otherwise entirely disconnected from the outer shell, and so dispensing with stays, bolts and crown bars, thus permitting easy removal.

The feature of the tender is a cylindrical instead of an U-Shaped tank, placed back of the coal space, the advantage being, a better distribution of the weight in the tender, less dead weight and more economical construction. The year 1901 was especially noticeable for the large volume of domestic business, there being a very large demand from the West and Southwestern Railroads; the Pennsylvania ordred over 150 locomotives of various types and the Baltimore & Ohio Railroad placed an order for over 100 locomotives. 1,375 locomotives were built, 526 being com-

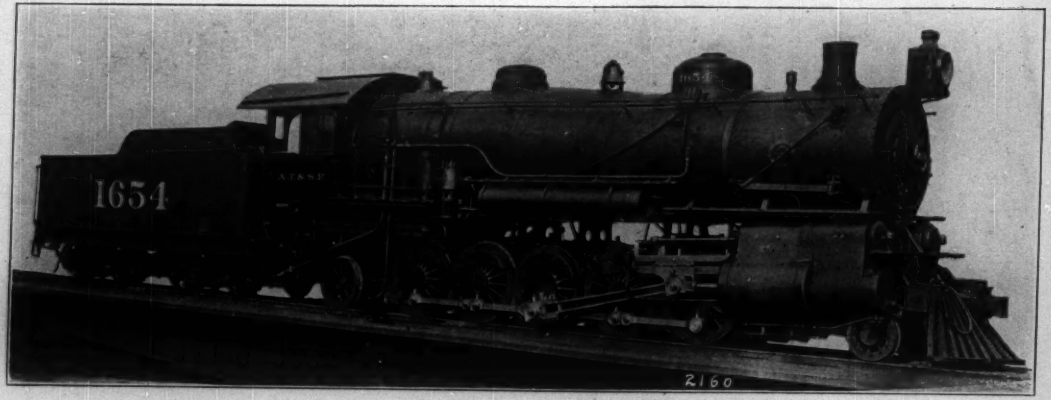


Fig. 11.—"Santa Fé Type."

pounds, six for compressed air and 45 electric. 208 were exported, and the average number of men employed per week was 9,595.

In February, 1902, the 20,000th locomotive was completed. This engine embodied several interesting features, viz.: compound cylinders, with the new arrangement, Vauclain type.

In May of this year, the largest locomotive ever built was turned out. It was a "Decapod," for the Atchison Railroad Company. The total weight of the engine alone was 267,800 lbs. It was designed for heavy hauling upon steep grades.

Two types of compound locomotives, the balanced and the tandem, both new in the practice of these works, were constructed in 1902. Both these types employ four cylinders. In the balanced engine they are placed side by side, with the two high-pressure cylinders between the frames, and the low-pressure outside. The high-pressure pistons are connected to a cranked axle. The inside and outside cranks on the same side of the engine are placed 180° apart so that the pistons oppose one another in movement and their disturbing effects are thus equalized. One piston valve controls the steam distribution to each pair of cylinders. The valve gear is arranged as in an ordinary single-expansion engine. This arrangement is particularly suitable for high speed pasesnger locomotives, as a more nearly perfect counterbalance can be effected. In the tandem type the high pressure cylinder is bolted to the front head of the low pressure with external bolts, which are easily accessible. The two pistons on the same side of the engine are mounted on a common piston rod. The packing between the two cylinders is so arranged that a steam-tight joint is maintained in spite of any wear which may occur in the various parts. The tandem arrangement of cylinders was one of the first to be employed on compound engines, but the Baldwin Locomotive Works introduced a number of valuable improvements. These features have been applied to more than 150 heavy freight locomotives built for the Atchison, Topeka & Santa Fé Railway.

The year 1902 also marks the introduction of the "Diamond" boiler seam, which has been used in a large number of locomotive boilers built at these works. The butt joint is covered on the outside by a narrow welt strip taking two rows of rivets, and on the inside by a diamond-shaped plate, which is secured to the shell by

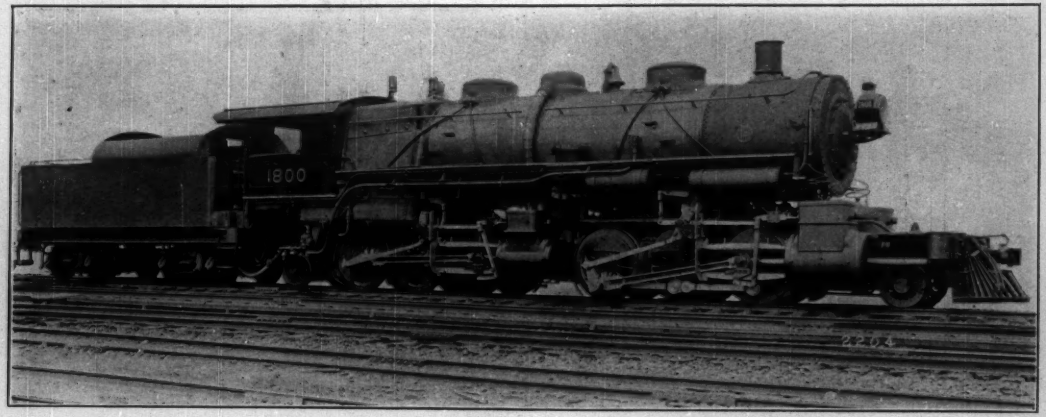


Fig. 12.—"Mallet Compound Type."

rivets placed in horizontal rows. The strength of this seam is estimated to be about 95% that of the solid plate. Another improvement relating to boiler seams adopted at these works about this time, consists in welding the boiler plate at each end of the horizontal seam where butt jointed seams are used. A stronger construction is thus obtained at the lap of the circumferencial seam and the scarfing or thinning down of the plates and covering strips at this junction is avoided. It also allows the sheets forming the two adjoining rings to be formed with a true radius, so that one will fit closely within the other for its entire circumference.

The "Mikado" type of locomotive was established this year. The requirements covered a powerful engine with a large fire box and ample grate surface for burning inferior coal or lignite. This type consisted of eight wheels connected, with the fire box behind them supported by a pair of trailing wheels, and a pony-truck in front.

Oil-burning locomotives were built this year for the "Atchison," the Southern Pacific and the Galveston, Houston & Henderson Railroads. Electric locomotives for surface and mine haulage showed a marked increase both in point of numbers and variety of design; also many orders for electric motor trucks were received.

In the year 1903, the "Santa Fé" type of locomotive was introduced for heavy freight service upon the Atchison, Topeka & Santa Fé Railway. These engines have five pairs of drivers connected, with a two-wheeled truck at each end. 150 of these locomotives are operating on this railway system, while others are being built.

78	locomotives	were	exported.
298	"	"	compounds.
1646	"	"	other types.
2022	"	"	constructed during the year

The years 1904 and &1905 witnessed no new developments, yet general improvements progressed and we find the number of locomotives constructed during these years to be:

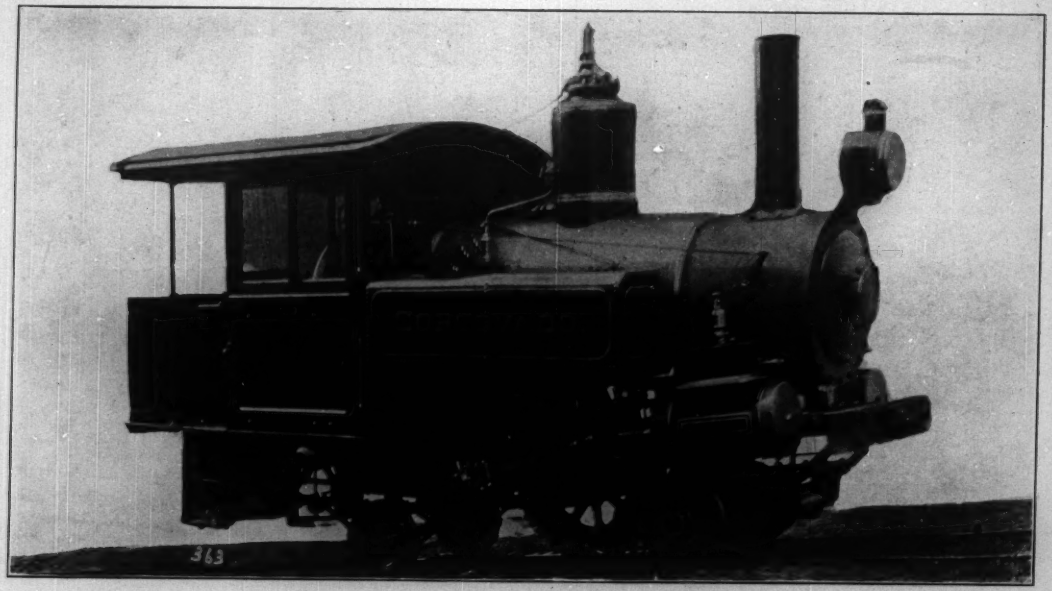


Fig. 13—"Riggenbach" System

	Exported.	Compounds.	Total.
1904	285	99	1453
1905	413	123	2245

Of the number of men employed:

In 1904 there were 10,573.
" 1905 " " 14,811.

In 1906, five locomotives of the "Mallet" type were built for the Great Northern Railway Company. A new feature in these locomotives, introduced by these works, was the addition of a two-wheeled radial truck at each end of the engine. This results in better curving qualities and reduces the flange wear on the leading pair of driving wheels. These engines are the heaviest thus far constructed in the experience of the works. The total weight of the locomotive is 355,000 pounds. The weight upon the drivers is 316,000 pounds. The weight of the engine and tender is 503,000 pounds. These locomotives are doing very excellent service upon the roads where they are employed. Forty additional ones have already been ordered owing to their good service.

Locomotives exported in 1906.....281
" compounds in 1906.....133
Total number in 1906.....2652
Number of men employed in 1906.....17,432

In compiling their report, the Committee have been obliged to give but a brief outline of the growth of these works; to overlook many interesting and valuable details of construction and patents, confining themselves to the fundamental patents and details which were essential to the successful development of their locomotives; and would recommend for originality, invention, design, workmanship, system and management, the award of the Elliott Cresson Medal and Diploma of the Franklin Institute, of Pennsylvania.

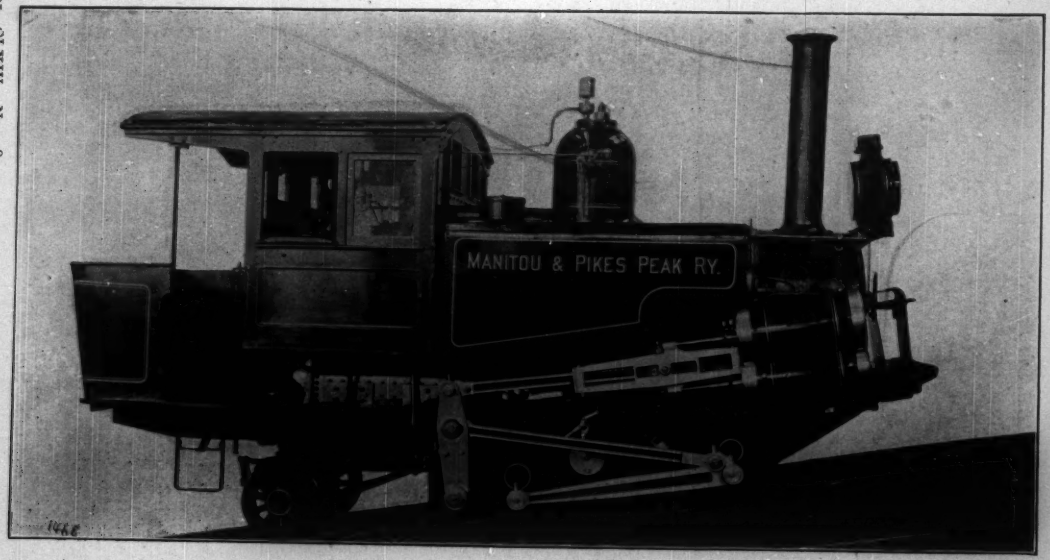


Fig. 14.—"Abt" System—Rack Rail.

APPENDIX.

RECAPITULATION.

Year.	Number of Engines Built.	Compound Locomotives.	Locomotives Exported.	No. of Men Employed.
1832	1			30
1833	0			
1834	5			
1835	14			
1836	40			
1837	40			300
1838	23			
1839	26			
1840	9		1	
1841	9		2	
1842	14		0	
1843	12		0	
1844	22		0	
1845	27		3	
1846	42		2	
1847	39		2	
1848	20		1	
1849	30		3	
1850	37		3	
1851	50		5	
1852	49		0	
1853	60		4	
1854	62		1	500
1855	47		5	430
1856	59		4	
1857	66		12	
1858	33		5	
1859	70		10	
1860	83		3	
1861	40		2	
1862	75		6	
1863	96		9	
1864	130		4	
1865	115		0	
1866	113		5	
1867	127		4	
1868	124		4	
1869	235		10	
1870	280		12	
1871	331		18	
1872	422		52	
1873	437		85	
1874	162		47	

Fig. 15.—"Four-Coupled Switch."

(Baldwin Locomotive Works.)

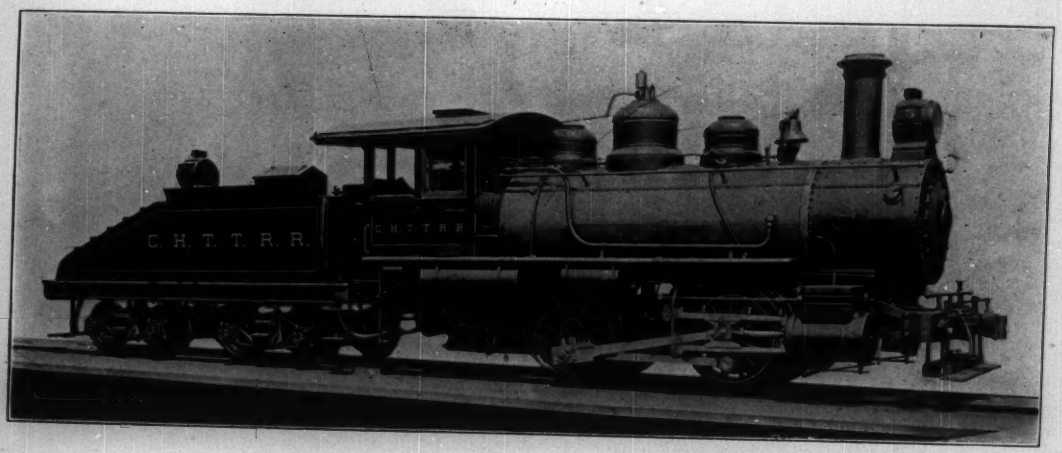


Fig. 16.—"Four-Coupled Switch."

Year.	Number of Engines Built.	Compound Locomotives.	Locomotives Exported.	No. of Men Employed
1875	130		30	
1876	232		47	
1877	185		37	
1878	292		79	
1879	308		90	
1880	577		53	
1881	554		89	
1882	563		119	
1883	557		151	
1884	429		170	2377
1885	242		82	1563
1886	550		42	2411
1887	653		46	2879
1888	737		93	3329
1889	827	1	211	3579
1890	946	3	144	4493
1891	899	82	290	4440
1892	731	213	127	4039
1893	772	160	162	4313
1894	313	30	132	2150
1895	401	51	151	2551
1896	547	173	289	3490
1897	501	86	205	3191
1898	755	235	348	4888
1899	901	241	375	6336
1900	1217	426	363	8208
1901	1375	526	208	9595
1902	1533	445	100	12158
1903	2022	298	78	14720
1904	1453	99	285	10573
1905	2245	123	413	14811
1906	2652	133	281	17432

Total number of engines exported up to January 1, 1907.....5614
Total number of engines (compound) up to January 1, 1907.....3325

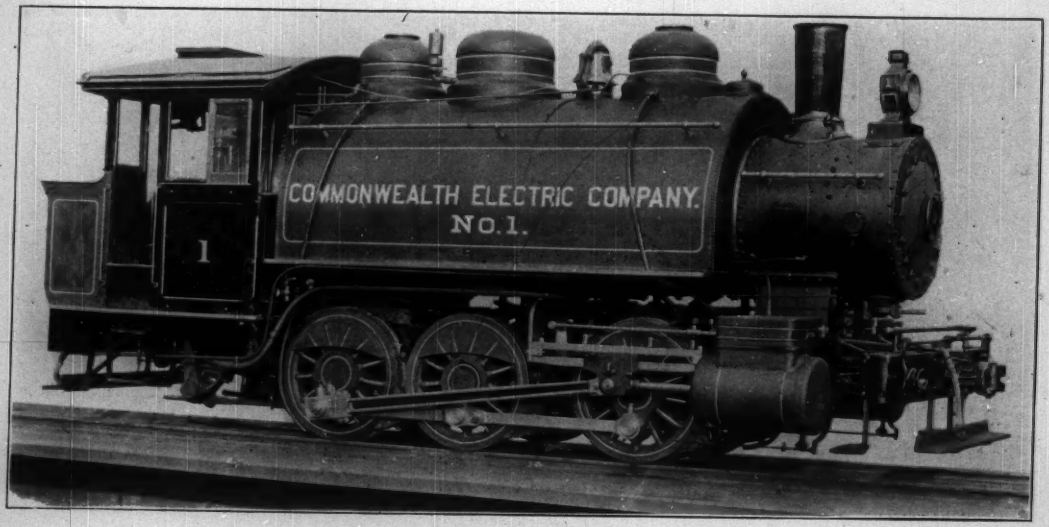


Fig. 17.—"Five-Coupled Switch."

Fig. 18.—"Six-Coupled Switch."

The present organization to date, based on an annual output of 2600 locomotives, is as follows:

Number of men employed		19000
Hours of labor per man per day		10
Principal departments, run continuously, hours per day		23
Horse power employed	Steam engines	12138
	Oil engines	4850
Number of buildings comprised in the Works		47
Acreage comprised in works	Philadelphia	17.8
	Eddystone	184.0
Acreage of floor space comprised in buildings		63.2
Number of dynamos for furnishing light (arc)		16
Number of dynamos for furnishing light (incandescent)		7
Horse power of electric motors employed for power transmission aggregate		14200
Number of electric lamps in service (incandescent)		7000
Number of electric lamps in service (arc)		951
Number of electric motors in service		1115
Consumption of coal, in net tons per week, about		3000
Consumption of iron, in net tons per week, about		5000
Consumption of other materials, in net tons per week, about		1460

Adopted at the stated meeting of the Committee on Science and the Arts, held Wednesday, April 3, 1907.

Attest:

WM. H. WAHL, *Secretary.*

(*Stated meeting held Wednesday, March 20, 1907.*)

The Secondary Current of the Induction Coil.

By H. Clyde Snook, A.M.

The purpose of this paper is to give a discussion of the currents flowing in the secondary of an Induction Coil, as observed by means of a Duddell High Frequency Oscillograph.

The principal apparatus used in this investigation consisted of a Duddell High Frequency Oscillograph and a twenty-inch Ruhmkorff Induction Coil, equipped with an electrolytic interrupter, a mercury jet interrupter, and a mechanically vibrating platinum contact break. A general view of the apparatus appears in Figure 1.

The Oscillograph is provided with a falling plate apparatus in the usual manner. The arc lamp which furnished the light for the moving beam that traced the curves is in the foreground near the falling plate arrangement. The mercury jet interrupter, a lead glass shield enclosing an X-Ray tube, and a milliampere meter for measuring the secondary current are in the left foreground.

Curves No. 12 to No. 20, inclusive, are of the current at the middle of the Induction Coil secondary, and were taken by inserting the oscillograph loop directly in series with the two halves of the secondary. The method of connecting up the apparatus was such that the only difference of potential between the oscillograph parts was due to the I. R. drop through the resistance of the oscillograph loop.

This was effected by connecting the permanent magnet of the oscillograph to one side of the loop and making a ground connection to earth at this point. It is true that the loop has a very slight self-induction and that there would be a very slight $L\frac{di}{dt}$ drop through it, and this would be added to the I. R. drop, but their sum is very small, so that the entire oscillograph is subjected

to very low differences of potential. By making the middle of the secondary a neutral point at zero potential, the induction coil secondary was permitted to develop its usual high potentials without endangering the recording apparatus.

No. 12 is of the current at the middle of the secondary, obtained in the manner just indicated, when there is no sparking at the terminals of the secondary coil. It is seen that current is

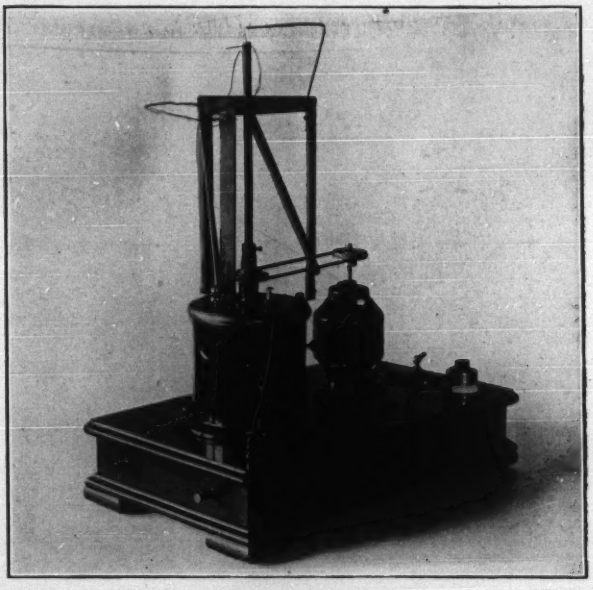


Fig. 1

flowing at the middle of the secondary winding even though no current is passing at the terminals. This is evidently due to the fact that the secondary is oscillating through its own self-induction and electro static capacity as an open-circuited Hertz resonator, the natural period of the thus self-constituted resonator being indicated by the shorter waves in each of the wave trains.

In this curve, as in a number of others, the zero line has been

shifted away from the true zero in order that the minute wave forms may be more clearly distinguished.

Curve No. 13 was taken under the same conditions as No. 12, with the exception that a bright snappy sparking was occurring at the secondary terminals of the induction coil. The effect of the sparking is seen in the extra tiny wiggles and the slight change in the contour of the larger waves, which latter effect is due to a change in the leakage inductance between the secondary and primary coils of the induction coil. One of the wave trains in this curve is seen not to have the tiny wiggles which are due to

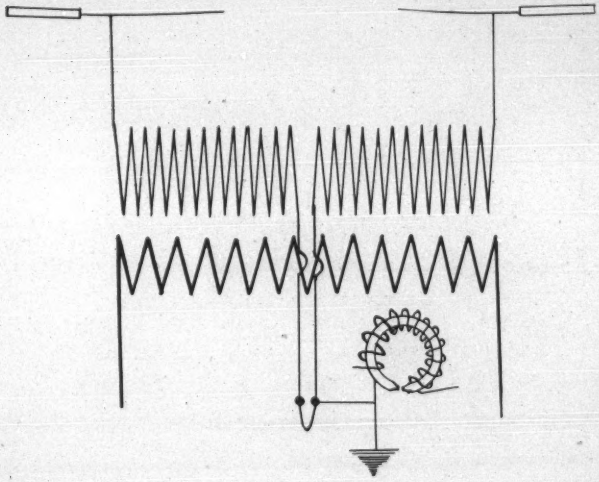


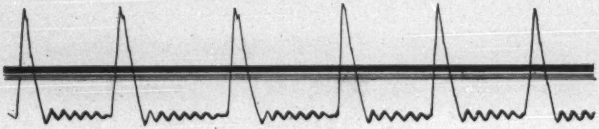
Fig. 2

the spark and its very high frequency oscillation which penetrates entirely through the secondary winding, but which has a still higher frequency than that of the natural period of the secondary winding when oscillating entire as an open-circuited resonator. On one of the wave trains it is seen that the spark failed to occur, and that the shape of the waves in this train is just the same as that in curve 12, where sparking did not occur.

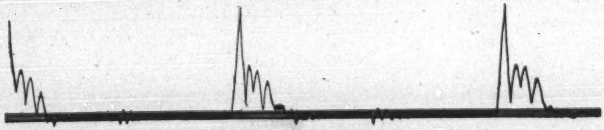
The previous curves, as well as this one, were obtained when the electrolytic interrupter was being used in the primary circuit

CURVE NO. 12.

CURVE NO. 13.

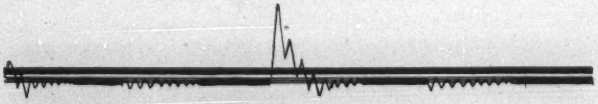


CURVE NO. 14.

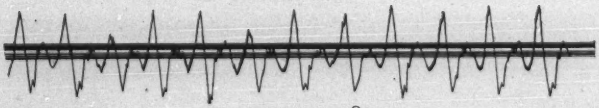


CURVE NO. 15.

CURVE NO. 16.



CURVE NO. 17.



CURVE NO. 18.

of the coil. This curve was obtained by permitting the secondary terminals to be only a few inches apart, and causing a heavy yellow flaming discharge to pass between them. The high wave peaks correspond to the "breaks" of the interrupter, and the tiny wavelets are again the oscillations of the same secondary but their time period is less than in curve No. 12 because in this instance the time period has been reduced by the lessening of the effective capacity of the ends of the secondary winding due to the low resistance of the flaming discharge.

When bright heavy sparking takes place at the secondary terminals, and the primary coil is operated by a platinum hammer break which is bridged with a moderate amount of condenser, we obtain a curve like No. 15. The self induction in the primary winding, when this curve was taken, was of medium value, and it, oscillating with the condenser bridged around the interrupter, caused the serrations in the main wave which occurs at "break." The regular and steady oscillations of the secondary are seen in a low wave train immediately preceding the large wave occurring at break.

No. 16 is quite similar to No. 15, but the electrolytic interrupter was employed. The saw teeth following the large wave occurring at "break" indicate very nicely the prolonged oscillation of the secondary. In this curve four milliamperes of current were being passed through an X-Ray tube having a parallel resistance of about two inches.

No. 17 is identical with No. 15, all adjustments being exactly the same excepting that the discharge was passed through a harder X-Ray tube, and it is seen that the current does not rise to so high an instantaneous value because of the increased tube resistance. The condenser oscillations are seen to serrate the wave form of the current at break, and when the latter has fallen to a low enough value they produce current of a negative sign.

By employing a low value of self induction in the primary coil, a high frequency of interruption by an electrolytic interrupter, and a soft X-Ray tube in series with the secondary, the current curve at the middle of the secondary is as in No. 18. The soft tube offers a low resistance to current of both positive and negative sign and a great deal of inverse current or current of negative value is seen in this curve.

Remembering that this curve is of current at the middle of the

secondary winding, we find a most interesting thing due to the superimposition of the high frequency secondary oscillations upon the low frequency oscillations of the primary condenser and self induction which assert themselves in the secondary through the mutual induction between the primary and secondary windings. This is seen immediately following the large positive waves which occur at break. Midway between the large waves at break can be seen the oscillations of the secondary occurring at "make" while the secondary oscillates as an open-circuited resonator, being maintained open circuited in this particular time by the high resistance of the X-Ray tube, which at this instant does not permit the passage of any current through it from the secondary winding. The conditions in the primary when this curve was taken were, a large primary self induction, a mechanical platinum interrupter shunted by a large mica condenser, and a period of interruption of about twenty-five cycles per second; while the secondary had in series with it a soft X-Ray tube, and a small spark gap.

No. 20 was taken under exactly the same conditions as was No. 19 excepting that the electrolytic interrupter was used in the primary. The wave form is profoundly altered and is characteristic of the wave forms produced with this type of interrupter.

We now proceed to examine the current not at the middle of the secondary winding but at one end of it, in order that we may obtain a true record of the current which actually passes through the X-Ray tube and thus eliminate the oscillatory current which occurs only in the secondary winding, and which moves under the stimulus of comparatively small electro-motive forces. It will be seen in the subsequent curves that in the majority of cases these secondary oscillations never pass through the X-Ray tube because their maximum potentials are insufficient to equal the ionization potentials of the X-Ray tubes.

This diagram indicates how the oscillograph was maintained at a zero potential as in the previous curves, but instead of having the current connection at the middle of the secondary it is placed at one end of it. The electrode of the tube which is connected to the oscillograph has of course a low resistance connection to it, and there is maintained at practically zero potential, one end of the secondary winding, the oscillograph, and one of the electrodes of the X-Ray tube.

In this connection it is interesting to note that some of these

succeeding curves are taken with the Kathode of the X-Ray tube maintained at zero potential, and some of them with the target maintained at zero potential. This was done in order to determine whether or not it is necessary to raise a kathode to a high *absolute* potential in order to cause it to emit kathode rays. It was found that the X-Ray tube behaved exactly the same in each case, no matter which way about the electrodes were placed with reference to the zero point, and the charactristics of the tube as to

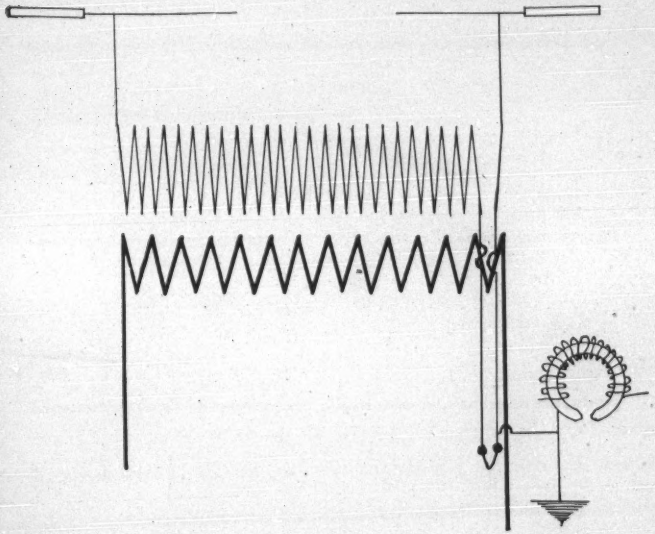
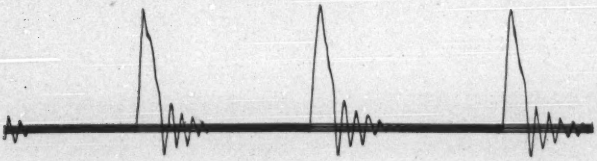


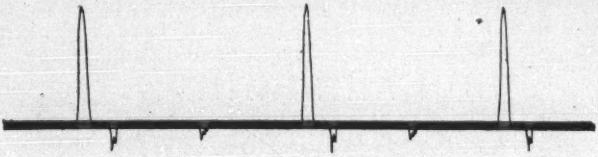
Fig. 3

resistance and emission of X-Rays remained absolutely the same in either position. It was therefore concluded that since no change in the tube characteristics was observed by making the kathode be at zero potential from the behavior of the tube when the kathode was made the high potential electrode, that the production of the kathode rays can take place at the surface of a kathode maintained at zero potential but between which and any other electrode in a Crooke's tube a sufficient difference of potential is maintained.

CURVE NO. 19.

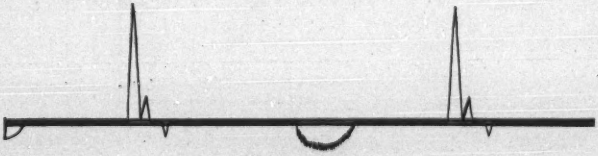


CURVE NO. 20.

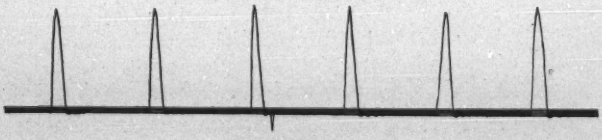


CURVE NO. 21.

CURVE NO. 22.



CURVE NO. 23.



CURVE NO. 24.

In this curve No. 21 we have the curve of current which actually passes through the X-Ray tube. It is seen that the maximum instantaneous value of the current is at times quite high but that the current lasts for very short intervals of time. If we take as land marks the tall peaks of positive current which comes at "break," we notice the negative current at "make," midway between these tall waves at "break." Immediately following the tall waves we see a negative wave of very short duration which is caused by the first semi-oscillation of the primary condenser which produced negative E. M. F. in the secondary, and it is to be noted that the succeeding condenser oscillations fail to produce sufficient potential to equal the ionization potential of the tube. The abruptness with which the current in the tube begins and ends at this semi-oscillation of the condenser, in spite of the fact that the current through the primary due to the condenser oscillation is a damped sine wave, proves the existence of a definite ionization potential for the tube. The oscillation due to the capacity of the tube electrodes, the wires leading to it and the secondary coil, are seen in small wavelets between the tall peaks of positive current and the negative wave caused by the primary condenser.

In No. 22 we have all the conditions the same as in No. 21, but the condenser and primary inductance have been adjusted so as to prevent the production of negative secondary potential of sufficiently high value to equal the negative ionization potential of the X-Ray tube. The curve is entirely above the line, which is as it should be, and is often exceedingly difficult to obtain.

If the X-Ray tube be very soft, its negative ionization potential is correspondingly low, and the negative voltage produced at "make" easily passes current through the tube in the wrong direction. In curve No. 23 midway between the tall peaks of current at the time of "break" we find a wave of current at "make" which lasts for a comparatively great length of time. In this curve can be seen a peak of positive and negative value due to the primary condenser oscillations. Serrating the negative curve at "make" can be seen the high frequency oscillations of the induction coil secondary.

This curve No. 24 is of current in an X-Ray tube when the current is passed through the tube in the proper direction, and there is none in the wrong direction. In this particular curve the in-

duction coil was excited by an electrolytic interrupter, the adjustment of which together with the adjustment of the number of turns on the primary and the rheostat in series with both and the source of current was such as to prevent the negative voltage from equaling the negative ionization potential of the tube.

We have here a mercury jet interrupter directly connected to the shaft of which is a hard rubber rod which has mounted at its upper end a metal rod which rotates around with it. This metal

Fig. 4

arm or rod in its rotation bears a definite phase relation to the "make" and "break" of the interrupter, and is so arranged that when the interrupter is at "break" this metal arm closes the secondary circuit of the induction coil through a very small air gap. When, however, the mercury interrupter is at "make" this rotating arm is at such a position that it has introduced into the secondary circuit a large spark gap, which is so great that the negative voltage produced in the secondary winding by the "make" of the interrupter will not bridge across this gap. This constitutes a synchronous series spark gap maintained in series with the sec-

ondary winding of the induction coil in such a way that it has a minimum resistance at the time of "break" and a maximum resistance at the time of "make," thus enabling us to prevent the passage into the external secondary circuit any current induced in the secondary at the time of "make." The speaker has used this apparatus in the manner indicated, and has taken oscillographic records of the curves obtained by it, and as would be expected they are the same as previously obtained without the use of such a synchronous series spark gap, excepting that there is not present in the curves any indication of current in the external secondary circuit at the time of "make."

This investigation of the currents flowing in the secondary of this particular induction coil was a part of a general investigation of various kinds of induction coils which was undertaken by the speaker under Dr. Arthur W. Goodspeed, Professor of Physics at the Randal Morgan Laboratory of the University of Pennsylvania. The speaker is greatly indebted to Dr. Goodspeed for his encouragement and his placing the use of the oscillograph and other apparatus at the speaker's disposal.

STRAWBOARD WASTE.

A recent publication of the United States Geological Survey that should have wide circulation in the States where strawboard is manufactured is a paper entitled "The Prevention of Stream Pollution by Strawboard Waste." The author is Mr. Earle Bernard Phelps.

The total waste discharged into the streams in 1900 amounted to 10,239,710,000 gallons of liquor, containing 184,777,382 pounds of straw and mineral matter and 77,191,660 pounds of lime. This enormous waste was discharged by fifty-nine plants or various sizes, but as most of these mills are along small streams the resulting pollution is very apparent.

Experiments conducted in the Sanitary Research Laboratory and Sewage Experiment Station of the Massachusetts Institute of Technology show that 93 per cent. of the suspended organic solids and 98 per cent. of the total suspended matter determined as turbidity can be removed, after a short period of sedimentation, by filtration of the liquor through sand, without coagulants. The present method, that of sedimentation in large fields, is pronounced unsatisfactory, expensive, and based on a wrong principle. The sludge resulting from the sedimentation tanks is declared inocuous after being pressed. It is said to make good soil and to have some value as a fertilizer.

UNDERGROUND WATERS OF THE COASTAL PLAIN OF TEXAS.

The underground waters of the Texas Coastal Plain, which during recent years have become of considerable economic importance, form the subject of a paper just issued by the United States Geological Survey as Water Supply Paper No. 190. The author is Prof. Thomas U. Taylor, of the University of Texas, who has spent a number of years investigating ground water conditions in that State.

The Coastal Plain of Texas is a continuation of the Atlantic Coastal Plain, although it differs from that area in many important features. It consists in general of a gently sloping plain, about 150 miles wide, lying between the Gulf coast and a line connecting Texarkana with Del Rio and running through Cooper, Greenville, Corsicana, Cameron, Elgin, and San Antonio. On the west, from Del Rio to the Colorado River, it is bordered by what is known as the "Edwards Plateau," and from Colorado River to the Arkansas State line by the "Black Prairie." Its area is about 75,000 square miles.

In eastern Texas the Coastal Plain has the general character of that of the Southern States; but in its southwestern extension that character is more or less modified, and it widens in the vicinity of Rio Grande, where there is a great embayment similar to that of the Mississippi. The surface rises gradually from sea level to an elevation of 800 to 1000 feet along the inner margin of the province. The region is traversed by many rivers, the largest being Neches, Trinity, Brazos, Nueces, and the Colorado. Of these only the Brazos enters the Gulf directly, all the others emptying into lagoons or bays. Notwithstanding its many streams much of the region is poorly drained, and in places water stands in lakes or ponds throughout the year.

Ground water, which is usually abundant throughout the district, has been used there for many years for general domestic purposes, and a few small irrigation plants have derived their water supply from this source. Within recent years artesian wells have been obtained in various parts of the region, the depth at which the water is found ranging from a few feet to over 2000 feet, with the average of about 600. Three of the largest cities in the region derive their entire city water supply from artesian sources. The flow of the wells varies from 20 to 16000 gallons per minute.

Professor Taylor's report discusses the water resources of this important district by counties and gives all available information, collected from many sources, concerning both shallow and deep wells. The many chemical analyses included indicate that, while the water of the Coastal Plain wells is more or less mineralized, the dissolved salts are as a rule neither objectionable for domestic purposes nor deleterious to plant growth. The report may be obtained by applying to the Director of the United States Geological Survey, Washington, D. C.

Section of Physics and Chemistry.*

On Shellac and a Method for the Determining of Its Impurities or Adulterants.

By H. Endemann.

Shellac has frequently been the subject of investigation. It is generally conceded that it consists mainly of oxy acids, wax, coloring, inorganic matter, etc.

A. Farner, Chem. Cent. Bl., 1899, p. 687, separated from the oxy acids one crystalline product which he called Aleuretic acid, which, as he judges, should yield when treated with permanganate of potash in alkaline solution azelaic acid and butyric acid. I may state here that I have also obtained a crystalline acid similar to that described by Farner, which, however, is not aleuretic acid, but rather a trioxy palmitic acid, of which more anon.

I will now describe the results of my own investigations, so far as they refer to my method of analyzing shellac in order to determine its qualities and purity.

In investigating shellac one should commence with the best and purest shellac of commerce. I chose the mark "D. C."

If such shellac is treated with a caustic alkali, it leaves an insoluble residue, the so-called "wax." In order to purify this I extracted it with boiling alcohol in a Sohxlet apparatus and purified the crystals so obtained by recrystallization from ether.

Analysis yielded:

Sample		Calculated for Myricyl-alcohol.
Carbon	82.18	82.08
Hydrogen	14.25	14.27

but no Cerylalcohol which requires C. 81.82, H. 14.16.

Manufacturers obtain the wax as the insoluble residue after dissolving shellac in a carbonate of soda solution.

[*Submitted for publication and approved. Ed.]

The carbonate of soda solution precipitated by an acid yields the main portion of the shellac apparently intact.

If the shellac, while in this alkaline solution, is bleached with hypochlorite of soda (as is done on the large scale) and subsequently precipitated with acid, the shellac is not obtained unchanged but containing chlorine. An analysis of bleached shellac showed in one case as much as 1.26% of chlorine. It would involve, therefore, considerable complications if bleached shellac were employed for an investigation of shellac constituents, though almost colorless products are at once obtained.

For the purpose of an investigation it is, therefore, far more desirable to select one of the "so-called" blond shellacs. Mark "D. C." has been used by me as a standard.

Shellac boiled with water yields a white crystalline acid (rhombic plates) to which we will refer later.

A solution of shellac in carbonate of soda boiled for one (1) hour connected with a carbonic acid absorption apparatus does not yield as much carbonic acid as would be expected from the quantity of acids contained in shellac.

2.5146 grams shellac with 1.0083 dry carbonate of soda and water were boiled and yielded 0.074 carbondioxide, while from later data 0.181 should have been expected, if the acids were really available, *i. e.*, in a free state. The stability of about two-thirds of the mass seems decidedly in favor of the assumption that these bodies are present as anhydrides.

That shellac is soluble in carbonate of soda solution has given rise to the assumption that it is a free acid. If it were, the whole of the calculated CO_2 should have been given up. In fact shellac acts precisely the same as many other oxy compounds, which show acid properties even in the absence of available carbonyl groups.

Hydration of shellac by means of caustic soda or potash produces Benedicts' liquid shellac, which leaves the myricyl alcohol behind. There is also another body set free, though only in minute quantity. When the distillation from which the myricyl alcohol has been eliminated is performed in a still it passes over with the water vapors. It possesses the odor of geraniol, but later on crystallizes. Working on a rather large scale I obtained from 100 shellac "D. C."—

4.5% Myricyl alcohol.
8.0% Acids (apparently not oxy acids, and not condensable by acids, and other impurities.)

87.5% { 27.0% of a water soluble acid (oxyacid crystallizable).
60.5% of an oily oxy acid, but slightly soluble in water,

besides coloring matter and other impurities. Hydration is established when we consider that 100 parts of shellac yields 104.5 parts products.

Dehydration may be reached in two ways. If shellac is kept liquid above its melting point for a considerable period of time it becomes gradually thicker and finally reaches a point when it becomes a gelatinous mass, which on cooling resembles rubber. This process is accompanied with a loss of weight.

This process can be much accelerated when we treat shellac with a concentrated mineral acid, like hydrochloric acid. It thickens at first, then, while moist, becomes like India rubber. The greater portion is insoluble in alcohol and always contains the wax and chlorine and for this reason is hardly useful for quantitative determinations in analytical work. Alcohol extracts from this about 8% of organic acid and inorganic salts, etc., not condensed or dehydrated by this treatment.

If liquid shellac is extracted with water, about 15% of a soluble crystallizable acid is easily removed. The rest, or about 12% more, is better removed by redissolving the residue in alkali and re-precipitating with acid from very dilute solution. It is then recovered from the aqueous solution after concentration and cooling.

Some of the insoluble, or rather very difficultly soluble, oily non-crystallizable acids, however, go into solution. In order to separate the latter, concentrate the solution somewhat until some of the acid will crystallize on cooling. This will carry the oily acid with it. The filtrate, on further concentration, will leave the crystallizable acid in a far higher state of purity.

Repeat this several times, using always the mother liquors for the purer product. The acid finally obtained by this manipulation is a pure white, very light, powder, which under the microscope appears in the form of rhombic plates or leaflets. One part dissolves in about 40 parts of water at the ordinary temperature. Oxidation with permanganate produced a very difficultly soluble acid which yields in the average

C. 57.33
H. 9.03

Hence resembling azelaic acid.

This crystallizable acid from shellac melts, when air dry, at 97.5° C.; and when dried under air pump, at 98.3° C.

Melted at 102° C. and tested next day melts at 89° to 94.5° C. (anhydride formed in part.)

On combustion this crystallizable acid yields, dessicator dry:

		Calculated for $C_{16}H_{32}O_5$.
C.	63.15	63.096
H.	10.53	10.614
Equivalent by titration	304 very sharp.	
In another preparation dried by heat,	301	304.3

This acid $C_{16}H_{32}O_5$ has, therefore, a composition corresponding to trioxypalmitic acid. Evaporated with hydrochloric acid the crystals do not reappear; either an anhydride or a lactone being formed. Chlorine also is present.

For instance, the crystallizable oxy acid when dehydrated by hydrochloric acid loses in weight 2.79% but it also contains 6.3% chlorine, very likely introduced into the acid by the reaction of the hydrochloric acid with one or more of the hydroxyl groups contained therein. The oily oxy acids behave the same; they lose in weight by heat and either substitute chlorine or add H. Cl. for the reason that they are unsaturated compounds.

Other rosins examined, and especially pine rosin, remain perfectly unchanged by the hydrochloric acid treatment.

Aleuretic acid $C_{13}H_{26}O_4$ was not met with, for its equivalent would be 246, according to Farner, but its composition of C. and H. yields figures very nearly those found by me, namely, C 63.4 H 10.6, and it melts at 101.5° C. The acid $C_{16}H_{32}O_5$ crystallizes well even in the presence of the liquid acid, and the melting point would be enhanced by some of this liquid acid being present, for the reason that in drying, preliminary to the determination of the melting point, a high temperature might be employed which would produce lactones of the liquid acid which do not melt readily. I dry either below 100 or by means of H_2SO_4 under the air pump.

It has been suggested that it was important to determine the actual constitution of this trioxypalmitic acid. I do not consider this necessary for a paper of this kind. However, the formation of azelaic acid would suggest the presence and position of one

hydroxyl group. It is certain only that the theory of Farner, that butyric acid would be formed while convenient to his aleuretic acid formula, could not be verified. 4.5 grms of trioxypalmitic acid treated in strongly alkaline solution with permanganate of potash, yielded after acidification a steam distillate practically free from volatile acid, requiring 0.032 NaOH for neutralization, and no odor of butyric acid. About 0.067 grms of an indifferent body could be extracted from the peroxide of manganese, and both are very likely but by-products of the reaction.

A great difficulty with these oxyacids exists in the ease with which they form anhydrides and lactones as is shown by the change in melting point and acidity, when they are subjected to high temperatures above 90° C. If the water thus lost were water of crystallization the acidity of the remaining bodies should be enhanced, but instead of this the acidity is lowered.

The liquid acid, or rather acids, have not been studied by try ing to isolate special compounds. As obtained they are mixtures of condensable as well as non-condensable acids, *i. e.*, such as are converted into lactones and anhydrides and such as are not. While under water, these acids are liquid, but when dried under the air pump, or at 85° to 90° C., they become quite thick and will no longer flow, resembling a very concentrated solution of gum arabic. Dried first under the air pump they still lose about 1.25% water when dried at 85° to 95° C. for twenty-four hours. On combustion they then yielded

Dried by heat below 98°C.	Dried under air pump only.
C. 65.76	64.94
H. 9.71	9.72

Equivalent by titration 288 (287.9) in water and alcohol mixed solution for sample dried under air pump only.

There is in this nothing to show but that, considering the ratio of C to H in this mixture it is evident that there is less H than in the crystallizable acid, leading to the conclusion that these acids are rather oleic oxy derivatives or such as are derived from other derivatives of the oleic series.

The combined shellac acids dehydrolized by hydrochloric acid, then extracted successively with boiling water, alcohol and ether left a residue

C. 67.87
H. 9.16

Besides these we find non-condensable acids, wax, coloring matter, etc. Iodine No. = 16.56. The non-condensable rosins of a good shellac possess a wax-like consistency and impart to the shellac elasticity, which cannot be accomplished by such rosins as pine rosin and similar hard alcohol soluble resins. These rather decrease the elasticity by distributing these good qualities of a normal shellac over a larger bulk. I examine, therefore, the physical properties of the non-condensable resins. They should show the consistency of a soft wax.

I have based upon these observations a method of analysis carried out in my laboratory for the past six years, which is as follows:

ANALYSIS.

Sand is incinerated for the destruction of organic material and subsequently extracted by hydrochloric acid, washed and dried and again ignited. This is far preferable to ground glass, which is partly dissolved by the H. Cl used in the subsequent treatment.

The shellac to be tested is always finely pulverized.

Two grams of shellac in a porcelain dish are intimately mixed with 10 grams of sand. The mixture is then moistened with about 4 c.c. of alcohol and shortly after with about 10 c.c. concentrated muriatic acid. Transfer to a water bath and evaporate to dryness. Repeat these manipulations once or twice and finally heat the dry residue in an air bath to 105 degrees C. for two (2) hours. After cooling add 20 c.c. 95% cold alcohol and let soak over night. Decant the alcohol through a filter into a weighed flask. The residue is then thoroughly disintegrated and repeatedly extracted by alcohol in 20 c.c. portions until the filtrate in the flask measures about 150 c.c. or more. If the alcohol is evaporated it leaves the rosins and fatty acids (not oxy acids) and not condensable by muriatic acid. If this residue is to be examined for pine rosin, dissolve some in concentrated sulphuric acid and sprinkle lightly upon it some cane sugar crystals.

In the presence of pine rosin at first a red violet coloration appears, which later becomes blue. Do not test the original shellac by this method.

These non-condensable rosins are those which mainly interest the merchants. They want to know how much of such incon-

densable rosins are present, or how much in excess of what is found in the best mark of commerce.

The best shellac contains about 8% of these non-condensable rosins, and anything in excess must be adulteration or show inferiority. Many have thought that the only thing of importance is the approximate determination of pine rosin or colophony, but my investigations have clearly shown to me that many brands of shellac with as much as 16% of alcohol soluble non-condensable rosins are perfectly free from pine rosin, while others containing no more are adulterated with pine rosin. Langmuir's iodine test exaggerates or diminishes the pine rosin present. So does McIlhenny's bromine method. For, for the same iodine number, we may calculate widely different rosin contents.

A shellac showing an iodine number = 71.62 contains according to Langmuir 25.5% rosin, but if we substitute the lowest or highest iodine Nos. of rosin in the calculation for actual rosin present, we obtain figures indicating 22% rosin or 34% rosin, a range of uncertainty amounting to 12%. Moreover, pine rosin is certainly not the only adulterant to be looked for.

If one contracted to furnish a shellac with no more than 20% rosin, to be determined by iodine absorption, one could easily add 5% and more in excess of one's contract and remain safe, provided one uses a pine rosin with a low iodine No. By my method this scheme is balked.

As said before, good pure shellac contains only about 8% of non-condensable and alcohol soluble rosin, salts, etc., yet I found shellacs which contain 16% of non-condensable rosins. These might be furnished from the plant upon which the insect is grown or might have been added. What we desire to know is the total of such not condensable rosins, or the excess over 8%. This non-condensable matter when obtained from the best shellac consists of about 15% of salt, alcohol and water-soluble organic matter derived from the shellac and 85% of resinous residue and fat.

A quantity over 8% of alcohol extracts is, however, not necessarily an adulterant. It is in part due to the manufacture of shellac from the crude material. This latter is packed in bagging, heated and pressed. The better shellac, the blond varieties, are obtained first. Reheating and additional pressure give higher colored varieties, which are also richer in this peculiar hard rosin found in shellac. They would, therefore, not be really

adulterated, but only indicate inferiority, though an addition of a similar rosin and not pine rosin is by no means out of the question. How much is due to the nature of the plants upon which the insect is grown cannot be determined here but only at the place of manufacture.

If the wax is to be determined this can be done in a separate portion, either by alcohol or by using a solution of carbonate of soda or caustic soda as the solvent and collecting the undissolved portion, which is the wax or myricyl alcohol.

The influence of hydrochloric acid incompletely removed from precipitated shellac also illustrates the formation of an alcohol-insoluble shellac after the same has been heated in boiling water and then spun and dried.

From the results obtained we calculate the actual addition of foreign rosins as follows:

Let the standard be 8% non-condensable matter and Y be the percentage quantity of such matter found in a shellac under examination. Then we have:

$(100 - 8) : 8 = (100 - Y) : X.$

and $Y - X$ is the quantity of non-condensable matter added to this shellac.

Say we find 13% non-condensable, then we have:

$92 : 8 = 87 : X.$ $X = 7.56\%$ due to the pure shellac in the mixture.

$13.00 - 7.56 = 5.44$ rosin added.

To test the method I used a shellac already adulterated giving non-condensable matter 12.22.

7.5 grms. of this shellac were melted together with 2.5 grms. of rosin.

From 1 grám of this mixture examined by my method 0.3425 were obtained as non-condensable. We then have

$87.78 : 12.22 = 65.75 : X;$ $X = 9.15.$

$34.25\% - 9.15\% = 25.1$ rosin added in place of 25% according to the mixture made, and in excess of the quantity already present.

I have been asked in all seriousness by so-called shellac experts, what is the use of examining shellac if not for pine rosin? If pine rosin were the only adulterant this question would be relevant. But pine rosin is not the only one, and it does not matter from the standpoint of the consumer or buyer

whether the resinous matter, in excess of a standard, is contained in the shellac as produced by the insect growing on a special plant or whether it has been added. This excessive resinous matter is harder and not wax-like and does not improve the shellac, and it is useless to ascertain its origin; it tends to deteriorate the shellac and should regulate the price downward.

To Mr. J. W. Paisley I herewith express my thanks for his valuable assistance.

Book Notices.

Gas, Gasoline and Oil Engines, including Producer-Gas Plants. A new, complete and practical work on gas, gasoline, kerosene, and crude petroleum engines, including producer-gas plants for gas-engine owners, gas engineers, and intending purchasers of gas-engines, fully describing and illustrating the theory, design, construction, and management of the explosive motor for stationary, marine, and vehicle motor power, by Gardner D. Hiscox, M.E. Including a list of United States patents issued on the gas-engine industry to the present time. A new book from cover to cover, entirely reset, revised, and enlarged. Illustrated by three hundred and fifty-one engravings. Fifteenth edition New York, Norman W. Henley, Publishing Co., 1906. 442 pages, 8vo. Cloth, price, $2.50.

The title fully describes the object of the work. The present edition includes the most recent information on the explosion motor and covers all branches of this growing industry.

The work will appeal to the gas engineer and all who are interested in this modern form of engine. The list of United States patents covers the subjects of gas, gasoline, and oil engines and their adjuncts from 1875 to date.

We also find here the rules and regulations of the Board of Fire Underwriters relating to the installation and management of gasoline motors.

R.

Resistenza dei Materiali e Stabilita delle Costruzioni ad uso degli Ingegneri, Capomastri costruttori, ecc. Ing. Dr. Guido Sandrinelli. Edizione completamente rinnovata del Manuale del defunto Pietro Gallizia. Manuali Hoepli. 471 pages, illustrations, 24mo. Milano, Ulrico Hoepli, 1905. Price, cloth, lire 5.50.

The engineer who has a working knowledge of Italian will find this little work useful. It is a reference book on the entire subject of the strength and resistance of materials in their relations to architecture and engineering. The writer has made free use of the standard works in other languages and has also drawn from the old Italian work of Pietro Gallizia. The result is a convenient little hand-book for the constructing engineer.

R.

La Ceramique Industrielle. Chimie-Technologie par Albert Granger. 644 pages, illustrations, 8vo. Paris, Gauthier-Villars, 1905. Price, cloth, 17 francs.

The work is a complete treatise on pottery, beginning with the raw material and taking the reader through the various stages to the finished product. Bricks, terracotta, earthenware, porcelain, all are treated. The chapters on coloring, glazing and enamels deal with the chemical as well as the practical side. The modern forms of ovens and kilns are described and illustrated.

The author has produced a convenient reference book, which is supplied with a good index and a brief vocabulary, in three languages, of the principal terms used in ceramics. R.

Experiments in Applied Electricity, by Arthur J. Rowland and William B. Creagmile. 181 pages, illustrations, 12mo. New York, McGraw Publishing Co. 1905. Price, cloth, $1.25.

This hand-book is intended to meet the wants of students in technical and manual training schools who have only a limited time to devote to the study of electricity.

The authors have had an experience covering several years, and while they have planned their little work to meet the needs, chiefly, of their own students of Drexel Institute, it can be introduced without inconvenience into any school where electricity forms a part of a course in physics. The experiments noted cover the subject of electrostatics, magnetism, battery and dynamo currents.

L'Année Technique, 1903-1904, par A. Da Cunha, préface par Henri Moissan. 303 pages, illustrations, 4to. Paris, Gauthier-Villars, 1904. Paper, price, 3.50 francs.

L'Annee Technique, 1905, par A. DaCunha, préface de Albert Dastre. 232 pages, illustrations, 4to. Paris, Gauthier-Villars, 1905. Paper, price, 3.50 francs.

These two volumes form a report of progress in the industrial arts of the world.

The subjects included are architecture and building, railroads and transportation, lighting and heating, and applied physics.

It is interesting to note the numerous reports on American achievements.

There are many good illustrations and the information is valuable. The series will be useful as a work of reference. R.

Die Hemmungen der Uhren, ihre Entwickelung, Konstruktion, Reparatur und Behandlung vor der Reglage, nebst zugehörigen Tabellen, zahlreichen Abbildungen und sechs Porträts. Allgemein verständlich für Uhr-Macher, Ingenieure, Techniker, u. s. w. bearbeitet von C. Dietzschold. 234 pages, illustrations, 8vo. Forming Vol. I of C. Dietzschold's Uhrmacher-Bibliothek. Krems a. D., the Author, 1905.

Horology has not been neglected by writers, but this is the first modern work which treats fully the subject of escapements. It covers development, construction, repairing, and handling, and describes all the important forms of escapements, historically, theoretically and practically. The work is well illustrated and carefully printed. The author intends publishing, at in-

tervals of two or three months, a series of volumes covering all the branches of watch- and clock-making. The first volume is a good beginning, and it is hoped that the undertaking will receive sufficient encouragement to make it possible to continue the series until the entire field is covered.

R.

Foods and their Adulterations; origin, manufacture, and composition of food products; description of common adulterations, food standards, and national food laws and regulations. By Harvey W. Wiley, M.D., Ph.D. 625 pages, 86 illustrations, 11 colored plates, 8vo. Philadelphia, P. Blakiston's Son & Co., 1907. Price, cloth, $4.00 net.

Dr. Wiley, in the preface of his new book, says in part: "This manual is descriptive in character and aims to give, within its scope, as thoroughly and intelligibly as possible, on account of the various food products in common use in their natural and manufactured conditions, with the usual adultrations which have been found therein. It includes information regarding Methods of Preparation and Manufacture, Food Values, Standards of Purity, Regulations for Inspection, Simple Tests for Adulterations, Effects of Storage, and similar matters pertaining to the subject. It has been designed to interest the consumer, as well as the manufacturer, the scientific as well as the general reader, all of whom it is hoped will find in it something useful. The consumer is entitled to know the nature of the product offered, the manufacturer and dealer the best methods of preparation. It will give the physician and sanitarian knowledge of the value of foods, their proper use and inspection, and, while not analytical in purpose, will provide the chemist with information which will guide him in his work of detecting impurities."

The crusade Dr. Wiley has made and is making in the interest of a nation fully aroused on the question of purer foods is well known. His extensive experience and the facilities he has at his command qualify him to write authoritatively and interestingly on this subject.

R.

Correspondence.

On the Speed of the Invisible Portions of the Spectrum. ADDITIONAL NOTE.

I desire to supply an unintentional omission in the Boyden Prize Memoir as published in the August number of the *Journal*. The reference is to the work of Hertz, who, in 1888, showed that the long electromagnetic ether-waves travel with a speed which differs from that of the visible light waves by less than one per cent., while their length is a million or more times as great. Our belief in the uniform speed of travel of the ultra red waves is therefore of the nature of an interpolation, while the similar assumption for the ultra violet waves was (until recently) an extrapolation.

PAUL R. HEYL.

The Franklin Institute.

(Proceedings of the stated meeting held Wednesday, September 18th, 1907.)

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, September 18th, 1907.

PRESIDENT WALTON CLARK in the chair.

Present, fifty members and visitors.

Additions to membership since last report, eleven.

The President called the attention of the meeting to the award of the Boyden Premium, which had been made by a committee of the Institute to Dr. Paul R. Heyl, of Central High School; and after expressing the satisfaction of the Institute at having been the instrument of executing Mr. Boyden's trust and at the award having been gained by a Philadelphia scientist, called upon the Secretary for a statement of the nature of the trust and the conditions of the award. The Secretary thereupon gave a detailed review of the entire subject.

At the conclusion of the Secretary's remarks he handed the President a certified check for the sum of One Thousand Dollars. The President then called Dr. Heyl to the floor, and after congratulating him on his achievement, formally presented the check to him. Dr. Heyl expressed his thanks and proceeded to give a description of the entire subject matter of his investigation. Dr. Heyl opened his remarks with a historical review of the status of the question propounded by Mr. Boyden at the time when the trust was instituted, in 1859; and noted that while the question was at the time one of the most mooted in physical science, it has since been relegated to one of secondary importance by the advance of science in general. There still remained, however, the requirement of a positive demonstration of the fact that had otherwise been determined by various analogies: that all rays of light and other physical rays travelled with the same velocity, and this demonstration he had been enabled to make photographically for the ultra-violet rays. Dr. Heyl's communication was mainly a popular statement of the data contained in his memoir on the subject already published and was illustrated with lantern slides and diagrams. At the conclusion of Dr. Heyl's discourse, in response to requests from the President, various aspects of the matter were reviewed successively by Dr. Robert Ellis Thompson, Principal of the Central High School; Prof. M. B. Snyder, Director of the Dept. of Physics; Prof. Harry F. Keller, Director of the Dept. of Chemistry, and Prof. Ernest Lacey, Director of the Dept. of English in the High School.

The President then introduced Mr. Louis Edward Levy, member of the Board of Managers, who, on behalf of the Institute, delivered a eulogy of the late Prof. Angelo Heilprin. During Mr. Levy's remarks a portrait of Prof. Heilprin was shown. Mr. Levy's remarks took the form of a memoir in which the life work of Prof. Heilprin was briefly reviewed.

At the conclusion of the meeting it was unanimously voted, on motion by Dr. Goldsmith, seconded by Dr. Williams, that Mr. Levy's paper be referred to the Committee on Publications with the recommendation that it be published in the *Journal*.

On motion, duly seconded, a vote of thanks was adopted and extended to the speakers of the evening, and the meeting was adjourned.

WM. H. WAHL, *Secretary.*

FRANKLIN INSTITUTE

Announcement

and

Program of Lectures

1907-1908

PHILADELPHIA: 15 S. Seventh St.

Issued October 1, 1907

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*Deceased.

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——— ———, Professor of Mechanical Engineering.
A. E. Outerbridge, Jr., Professor of Metallurgy.
H. W. Wiley, Professor of Agricultural and Hygienic Chemistry.
Carl Hering, Professor of Electrical Engineering.
Joseph W. Richards, Professor of Electrochemistry.
Rudolph Hering, Professor of Sanitary Engineering.
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——— ———, Chemistry of Textures and Pottery.
Waldemar Lee, Chemistry of Oils, Fats and Fermentation.
Louis E. Levy, Graphic Arts.
——— ———, Structural Engineering.
John McArthur Harris, Architecture.

Instructors.

Wm. H. Thorne, Mechanical and Architectural Drawing.
M. H. Keil, Naval Architecture.
L. M. Arkley, Machine Design.

COMMITTEES

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On Meetings, Washington Jones, Chairman.
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Section of Photography an.. Microscopy.—Henry Leffmann, President; M. I Wilbert, Secretary.

Electrical Section.—Thomas Spencer, President; Richard L. Binder, Secretary.

Mining and Metallurgical Section.—G. H. Clamer, President; ——— ———, Secretary.

Mechanical and Engineering Section.—Charles Day, President; Francis Head, Secretary.

COMMITTEE ON SCIENCE AND THE ARTS.

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Carl G. Barth,	Harry F. Keller,
Richard L. Binder,	Waldemar Lee,
Hugo Bilgram,	Louis E. Levy.
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Jos. H. Burroughs,	Luther D. Lovekin,
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Robert Job,	Chas. J. Zentmayer.

FRANKLIN INSTITUTE.

THE FRANKLIN INSTITUTE, OF THE STATE OF PENNSYLVANIA, FOR THE PROMOTION OF THE MECHANIC ARTS, was founded in the year 1824. The purpose of its founders is plainly set forth in its corporate title, and the means employed in the furtherance thereof are concisely stated in the following:—

LIBRARY.

At the present time the library contains 61,122 volumes, some 44,644 pamphlets, 2,939 maps and charts, and 1,250 photographs, classified and catalogued. It is exclusively scientific and technical in character and is steadily increasing in numbers and importance. It embraces, in addition to the standard and current works on mechanics, physics and chemistry, pure and applied, the publications of the principal scientific and technical societies of the world, files of 565 domestic and foreign scientific and technical serials, and sets of the British (and Colonial), French, German, Austro-Hungarian, Russian, Swiss, Finnish, and American patent records. The library is also designated under the Act of Congress as the repository of the Government publications of the Congressional District in which it is located. Special attention has been given for a number of years to the collection of

state and municipal reports relating to public works, water supply, sewerage, health, reports of railway and other important corporations, etc., which are rarely preserved in complete form in libraries, on which account this branch of the library has become extremely valuable. The extent and general state of completeness of the above-named official publications, and especially of the serials, make this collection particularly useful as a reference library.

The library is open as follows: Mondays, Tuesdays, Wednesdays, Fridays, 9 A.M. to 6 P.M.; Thursdays, 9 A.M. to 10 P.M.; Saturdays 9 A.M. to 5 P.M.; third Wednesday of each month 9 A.M. to 10 P.M. (5 P.M. from June 1st to September 16th; Saturdays, 12 M.) The library is closed on Sundays and on state and national holidays.

It is accessible to members in good standing for use and reference at all times, between the hours above named; and to the public, *for reference to public documents only*, between the hours of 10 A.M. and 3 P.M. A Librarian, with several assistants, is in charge of the library, under the general direction of the Secretary and the Committee on Library.

(Members are requested to present to the library copies of books, magazines, and pamphlets which they do not wish to preserve. A card addressed to the Librarian, notifying him when and where to send for such gifts, will receive prompt attention.)

LECTURES.

Formerly it was customary for the Committee on Instruction, with the co-operation of the professors, to arrange each year a course of about twenty-five lectures of a scientific or technical character. Experience has demonstrated, however, that it would better meet the general wish of members to restrict the Institute lectures, as far as practicable, to such as can be made attractive and entertaining, especially by means of illustrations.

The program of the Lecture Course for the season of 1907-1908 will be found elsewhere.

SCHOOLS.

The Institute maintains the following technical schools, viz:—

A Drawing School, embracing instruction in Mechanical, Architectural, and Free-Hand Drawing.

A School of Machine Design, embracing Elementary Mathematics and the Principles and Application of Machine Design.

A School of Naval Architecture, embracing Theoretical Naval Architecture and the Design and Construction of Ships.

The sessions of these schools are held *in the evening*, in order to give young men engaged in workshops and elsewhere during the day, the opportunity of profiting by them without interference with their daily occupation.

There are two courses (winter and spring) of three months each; the first beginning about the middle of September and ending in December; the second, from January to the middle of April.

Applicants for admission to the schools may obtain a special circular giving a synopsis of the several courses of instruction, details of the term periods of the classes, the school evenings, price of instruction, etc., by applying at the office of the ACTUARY, in the HALL OF THE INSTITUTE, 15 SOUTH SEVENTH STREET.

A general account of the character of the work of the schools is given herewith:—

Drawing School.—A school of instruction in Drawing, embracing the Mechanical, Architectural and Free-Hand branches, has been maintained uninterruptedly since the foundation of the Institute. It is in charge of a Director and several assistants, under the general direction of the Committee on Instruction, and at present is in a flourishing condition, both in respect of the means and methods of instruction and the number of its pupils.

School of Machine Design.—The aim of this school is to bring within the reach of draughtsmen, practical mechanics and others interested in the design of machinery, who have not found the opportunity of a technical education, a systematic and logical exposition of the principles and application of machine design, under conditions that require no interruption of their business pursuits. This was originally sought by establishing the School of Elementary Mathematics, in which the necessary preliminary training in mathematics was offered. During the two years of its existence as a separate school, a demand arose for a definite course in machine design, which has been met by merging the mathematical course with the subjects which comprise a course in machine design.

The full course extends over four years.

The first two years of the course are devoted exclusively to Mathematics, after which Theoretical Mechanics, Strength of Materials, Machine Design and Kinematics of Machinery are discussed as scheduled in the synopsis. Instruction will be carried on by lectures, illustrated by blackboard demonstrations and the solution of numerical problems. In addition, test and drill problems, to be solved out of class, will be assigned. The latter part of the work in Machine Design will consist in computing the proportions of some machine of standard type and preparing complete working drawings from them. In Kinematics of Machinery, also, drawing-board problems will form an essential part of the work.

For the best results and most general and satisfactory treatment of these subjects, an elementary knowledge of the methods of the Differential Calculus is desirable, in fact, almost indispensable in the discussion of certain theorems in applied mechanics, though in most cases it can be replaced by special methods involving

only elementary mathematics. These special methods will be freely used, but an attempt will be made to gradually introduce the more advanced and logical method in the discussion of the technical subjects, and in the future to make place for it—when it can be treated more thoroughly—in the mathematical course.

Those who have satisfactorily completed the full course will be awarded a certificate of study. Those who complete the mathematical work only, may receive a certificate covering that branch.

School of Naval Architecture.—The scope of this school as at present organized covers Theoretical Naval Architecture and Ship Design and Construction. It is contemplated in time to extend the course of instruction to embrace also the subject of Marine Engineering. The courses are so devised and arranged as to meet in the most practical way the needs of the young men engaged in the shipyards who may wish to qualify themselves for the higher branches of the ship-builder's art.

JOURNAL OF THE FRANKLIN INSTITUTE.

The Franklin Institute began, in the year 1826, the publication of a *Journal*, devoted to Science and the Mechanic Arts, which has been continued uninterruptedly to the present day. It contains the record of the scientific and other useful work of the Institute, besides many valuable contributions relating to the growth of American industries and the progress of science and the useful arts in general during the past three-quarters of a century.

The *Journal* has an acknowledged position at home and abroad as a standard work of reference.

The complete file of the *Journal* embraces: The *Franklin Journal* (4 vols.), 1826-1827; the *Journal of the Franklin Institute*, second series (26 vols.), 1828-1840; the *Journal of the Franklin Institute*, third series (134 vols.), 1841 to the present; or 164 volumes in all.

In its present form the *Journal* is an octavo of 80 pages. It is issued monthly. The six issues of each half year (January to June, and July to December) constitute a complete volume, with index and title-page.

The *Journal* is edited by a Committee on Publications with the assistance of the Secretary of the Institute. The subscription price is *Five Dollars* per year. *The Journal is sent to all members in good standing without charge.*

The first part, embracing the first 120 volumes (1826-1885), is sold at *Five Dollars.*

The second part (1886-1895) is sold for *One Dollar and Fifty Cents.* Sent post-paid on receipt of price.

A third part (1896-1905) is now in press.

MEETINGS OF THE INSTITUTE.

The Institute meets on the *Third Wednesday* of each month (except in July and August). At these meetings papers on important scientific and technical subjects are read and discussed, or new inventions are exhibited and described, or a report on current matters of interest in science and the useful arts is presented by the Secretary. The meetings are held in the Lecture Room. The chair is taken at 8 o'clock P.M. Members may introduce friends. Visitors are requested to leave their cards with the doorkeeper. On meeting evenings the Reading Room will remain open until 10 P.M.

COMMITTEE ON SCIENCE AND THE ARTS.

This Committee was originally the Committee on Inventions. It was formed in 1834, and from that date to the close of 1886 was constituted of volunteer members. At present the Committee consists of sixty (60) members, chosen at the annual election, twenty each year, who pledge themselves to investigate and report upon the merits of such inventions as may be submitted to them for that purpose, and to perform such other duties as may be referred to the Committee by the Institute. In its time this Committee has examined and reported upon a great number of inventions, and many worthy persons are indebted to its counsel and aid for the successful introduction of their inventions, or have been dissuaded from wasting time and money upon impracticable ideas. It has investigated and reported upon numerous subjects referred to it by the Institute, and by its labors has assisted notably in maintaining the scientific reputation of the Institute. The work of the Committee on Science and the Arts is done gratuitously. The meetings of this Committee are open to all members of the Institute.

This Committee has been intrusted by the Institute with the authority to grant the *Elliott Cresson* Gold Medal and the *Edward Longstreth* Medal of Merit, and to recommend the grant of the *John Scott Legacy* Premium and Medal, for discoveries and inventions of conspicuous merit.

Persons desiring to submit their inventions to this Committee will be furnished by the Secretary with a printed copy of the rules and a blank form of application.

(A list of the Committees as at present constituted appears elsewhere).

SECTIONS.

Members of the Institute who may wish to become associated in order to devote themselves to special branches of science and the useful arts may organize a Section for that purpose, in accordance with certain prescribed regulations. (*See the By-Laws.*)

The By-Laws provide that "*all members of the Institute shall have the privilege of enrolling them-*

selves without payment of additional fees, as members of any of the Sections which are now, or which may hereafter be established."

At the present time there are in existence five Sections, to wit, a Section of Physics and Chemistry, Section of Photography and Microscopy, an Electrical Section, a Mining and Metallurgical Section, and a Mechanical and Engineering Section, having a combined membership of about three hundred. The meetings of the Sections are held in the Hall, and *are open to all members of the Institute.*

The Sections meet on each *Thursday evening of the month* at 8 o'clock (except in July and August). These meetings are devoted principally to reading and discussion of papers on original investigations germane to the objects of the Sections. A list of communications thus far arranged by the Sections appears elsewhere. Members enrolled in the Sections receive special card notices announcing the program of each week. Special meetings will be specially announced. On meetings nights the Library is open until 10 P.M.

EXHIBITIONS.

The first exhibition of American manufactures in the United States was held, under the direction of the Franklin Institute, in the year 1824, in the old Carpenter's Hall, in Philadelphia.

Since that notable event the Institute has held twenty-nine exhibitions. The last was the National Export Exposition, held in 1899 in co-operation with the Philadelphia Commercial Museum.

SCHEDULE OF MEETINGS.

1907-1908.

(Institute and Section meetings are all held on WEDNESDAY and THURSDAY evenings, except when these fall on legal holidays.)

First Wednesday of each month (except July and August), at 8 P.M.

COMMITTEE ON SCIENCE AND THE ARTS.

Second Wednesday of each month, at 1.30 P.M.
BOARD OF MANAGERS.

Third Wednesday of each month (except July and August), at 8 P.M. INSTITUTE.

Thursday evenings, 8 o'clock (except in July and August.) GENERAL SECTION MEETINGS.

	Committee on Science and the Arts	Board of Managers	Institute
1907			
October	2	9	16
November	6	13	20
December	4	11	18
1908			
January	.	8	*15
February	5	12	19
March	4	4	18
April	1	8	15
May	6	13	20
June	3	10	17
July	.	8	..
August	.	12	..
September	2	9	16

Thursday evening of each week, 8 o'clock, except in July and August. } Section meeting.

*The Annual Meeting.

MEMBERSHIP.

TERMS AND PRIVILEGES.

The members of the Institute are divided into the following classes, viz.: *Contributing Members, Stockholders, Life Members, Permanent Members,* and *Non-resident Members.*

Any person of legal age friendly to the mechanic arts is eligible to membership in the Institute. Candidates must be proposed by a member in good standing, and elected by the Board of Managers.

Terms.—Contributing members pay Fifteen Dollars each year. The payment of Two Hundred Dollars in any one year secures Life Membership, with exemption from annual dues.

Stock.—Second-class stockholders pay an annual tax of Twelve Dollars per share, and the holder of one share is entitled by such payment to the privileges of membership.

Privileges.—Each contributing member (including non-residents) and adult holder of second-class stock is entitled to participate in the meetings of the Institute, to use the Library and Reading Room, to vote at the Annual Election for officers, to receive tickets to the lectures for himself and a lady, to attend the Section meetings and to receive one copy of the *Journal* free of charge, and additional copies at Three Dollars per year.

Permanent Members.—The Board of Managers may grant to any one who shall in any one year contribute to the Institute the sum of One Thousand Dollars a permanent membership, transferable by will or otherwise.

Non-resident Members.—Newly elected members residing permanently at a distance of twenty-five miles or more from Philadelphia may be enrolled as Non-resident Members, and are required to pay an entrance fee of Five Dollars, and Five Dollars annually. Non-resident Life Membership, $75.00.

Contributing members, if eligible, under the non-resident clause, on making request therefor, may be transferred to the non-resident class by vote of the Board of Managers, and are required to pay Five Dollars annually.

Resignations must be made in writing, and dues must be paid to the date of resignation.

MEMBERSHIP BADGES.

The design of the Institute's membership badge is circular in form, with a diameter equal to that of a dime. In the center, in high relief, appears a profile bust of Benjamin Franklin, a reduced copy of that used on the Franklin Institute Medal. Surrounding the bust is a ribbon of blue enamel, inscribed in which are the words: "Franklin Institute, 1824." The finish is blue and gold, the metal work being thoroughly and heavily plated with gold, and all work done in a first-class manner.

The Board of Managers has fixed the price of the badge, to members in good standing, at $1. It may be had either in the form of a button, a pin or a pendant. In solid gold the price is $5. All badges are numbered, and the owner's name and number recorded.

CERTIFICATE OF MEMBERSHIP.

Certificates of membership of handsome design, suitable for framing, 19 x 24 inches in size, may be purchased by members in good standing at the price of $1.

PROGRAM OF LECTURES.

SEASON 1907-1908

To be delivered in Lecture Hall, Franklin Institute, 15 South Seventh Street.

LECTURES BEGIN AT 8 O'CLOCK P.M.

☞The Committee on Instructions expects to arrange for the season 1907-1908 a series of *six (6) profusely illustrated popular scientific lectures*, which will be delivered in the Lecture Hall of the Franklin Institute.

The list (subject to change) is as follows:—

1907 (First Series.)

AUTUMN COURSE, 1907.

Friday, November 1st, DR. THOMAS E. WILL, Secretary American Forestry Association, Washington, D. C.
Forestry; with Especial Reference to the Appalachian Natural Forests.

Friday, November 15th, DR. HENRY LEFFMANN, Philadelphia, Pa.
Diamonds and Diamond Mining.

Friday, November 29th, DR. FULLERTON L. WALDO, Secretary of the Civil Service Reform Association of Pennsylvania.
The Panama Canal.

1908. (Second Series.)

WINTER COURSE.

The definite arrangement of these lectures to be given in January and February, 1908, will be announced later in the season.

Provisional engagements (subject to change), have been made with the following lecturers:—

Friday, January 31st, ANDREW WRIGHT CRAWFORD, Philadelphia, Pa.
The Proposed Boulevard for Philadelphia.

Friday, February 14th, PERSIFOR FRAZER, Dr. ès Sci. Nat., Philadelphia, Pa.
Subject to be announced.

Friday, February 28th, PAUL A. SPENCER, A.B., M.E., Philadelphia, Pa.
Long-Distance Electric Transmission.

NOTICE.—Admission to these lectures will be reserved to members of the Institute and friends. Members will be admitted to the Lecture Hall on presentation of their membership ticket, which will admit *member and friends.*

PRELIMINARY PROGRAM OF THE SECTIONS

1907-1908.

A preliminary list is presented herewith of Section papers and communications. This will be supplemented from time to time by the Executive Committees of the Sections as additional arrangements are made.

By unanimous vote of the Executive Committee of the several Sections, THURSDAY EVENING of each week during the season excepting legal holidays, is designated as Section evening. Each Section in turn will arrange the weekly program, and members of all the Sections will meet weekly in joint session.

Members of the Sections will receive due notice of the Thursday evening meetings.

[MEMBERS OF THE INSTITUTE HAVE THE PRIVILEGE OF ATTENDING ALL MEETINGS OF THE SECTIONS.]

1907-1908.

The Pitometer.
EDWARD S. COLE, Manager The Pitometer Co., New York.

The Electrothermic Production of Iron and Steel.
DR. JOSEPH W. RICHARDS, Lehigh University, Bethlehem, Pa.

Automatic Telephone Systems.
J. W. LATTIG, Vice-Pres. and Gen'l Mgr. The American Telephone Co., Rochester, N. Y.

Wood Turpentine and its Derivatives.
F. P. VEITCH, U. S. Dept. of Agriculture, Washington, D. C.

Moving Pictures and How they are Made.
S. LUBIN, Philadelphia, Pa.

The Jerseyite.
DR. EDWARD GOLDSMITH, Philadelphia, Pa.

Some Recent Work in Metallography.
DR. WM. CAMPBELL, Columbia University, New York.

The Mercury Arc.
F. H. VON KELLER, Manager, Cooper-Hewitt Electric Co., New York.

An Improved Range Finder.
LOWNDES TAYLOR, West Chester, Pa.

Improved Instruments for Navigation.
DR. HENRY EMERSON WETHERILL, Philada.

The Present Status of Sewage Disposal.
GEORGE A. JOHNSON, Sanitary Eng., New York.

Electrical Measurement Apparatus.
E. F. NORTHRUP, The Leeds & Northrup Co., Philadelphia, Pa.

Steel Rails.
Discussion opened by ROBERT JOB, Philada.

Radio-Active Minerals in Pennsylvania.
EDGAR T. WHERRY, Ph.D., Philadelphia, Pa.

The Medical Uses of the X-Rays.
WM. S. NEWCOMET, Philadelphia, Pa.

Development in Turbine Design.
RICHARD H. RICE, Gen'l Electric Co., West Lynn, Mass.

Gas and Gasoline Engines.
H. S. BALDWIN, Eng. Dept. Gen'l Electric Co., West Lynn, Mass.

Protective Coatings: Failures and Successes.
G. B. HECKEL, Sec'y of the Paint Mfr's Association of the U. S., Philadelphia.

Corrosion of Iron and Steel.
ALLERTON S. CUSHMAN, U. S. Dept. of Agriculture, Washington, D. C.

Effect of Smelter Fumes on Vegetable and Animal Life.
J. K. HAYWOOD, U. S. Dept. of Agriculture, Washington, D. C.

The Revolutionizing of Electric Domestic Lighting.
F. M. F. CAZIN, Hoboken, N. J.

The Supposed Transmutation of the Elements.
DR. H. F. KELLER, Central High School, Philadelphia, Pa.

Vanadium in Steel.
DR. RICHARD MOLDENKE, Sec'y Am. Foundrymen's Association, Watchung, N. J.

Experiments with Sand Filtration.
W. B. FULLER, Dept. of Water Supply, Gas and Electricity, New York.

Scamoni's Contributions to the Development of the Modern Graphic Arts.
LOUIS E. LEVY, Philadelphia, Pa.

Recent Developments in Wireless Telegraphy and Telephony.
C. D. EHRET, Counsellor-at-Law, Philada.

Working Standards of Light and their Use in Photometry.
CHAS. O. BOND, Chief Photometrist, United Gas Imp't Co., Philadelphia.

Deflocculated Graphite.
E. G. ACHESON, Niagara Falls, N. Y.

Recent Developments in the Metallurgy of Zinc.
W. McA. JOHNSON, New York.

The Telepost.
PATRICK B. DELANEY, New York.

Reinforced Concrete and its Use in Construction.
RICHARD L. HUMPHREY, Philadelphia, Pa.

The Equipment of Country Houses and Farms with Electricity.
PUTNAM A. BATES, Consulting Electrical Engineer, New York.

Some Practical Investigations into the Character Structure and Uniformity of Mild Steel.
CHAS. L. HUSTON, Vice-Pres. Lukens Iron and Steel Co., Coatesville, Pa.

Cement: Its Use and Abuse.
ROBT. W. LESLEY, Philadelphia, Pa.

Solid Steel Ingots.
N. LILIENBERG, Metallurgical Engineer, Philadelphia, Pa.

The Process and Apparatus for the Production of Carbon di Sulphide in the Electric Furnace.
EDWARD R. TAYLOR, Penn Yan, N. Y.

Maple Products.
ALBERT P. SY, Buffalo, N. Y.

The Electron Theory.
DR. EDWARD A. PARTRIDGE, Central Manual Training School, Philadelphia, Pa.

The following speakers will announce the subjects of their communications later on:

DR. HENRY LEFFMANN, Consulting Chemist. Philadelphia, Pa.

JAMES CHRISTIE, Mechanical Engineer, Phila.

G. H. CLAMER, Metallurgical Engineer, Phila.

FRANCIS A. J. FITZGERALD, Elec. Engineer, Niagara Falls, N. Y.

WM. J. HAMMER, Electrical Engineer, New York.

DR. ROBT. H. BRADBURY, Southern Manual Training School, Philadelphia.

H. CLYDE SNOOK, Roentgen Mfg. Co., Phila.

RICH'D H. EDMONDS, Ed. "The Manufacturers' Record," Baltimore, Md.

J. W. RIDPATH, Jenkintown, Pa.

DR. CHAS. F. HIMES, Carlisle, Pa.

PROF. WILBUR M. STINE, Swarthmore Pa.

The following named gentlemen have authorized the announcement of their names as probable contributors:

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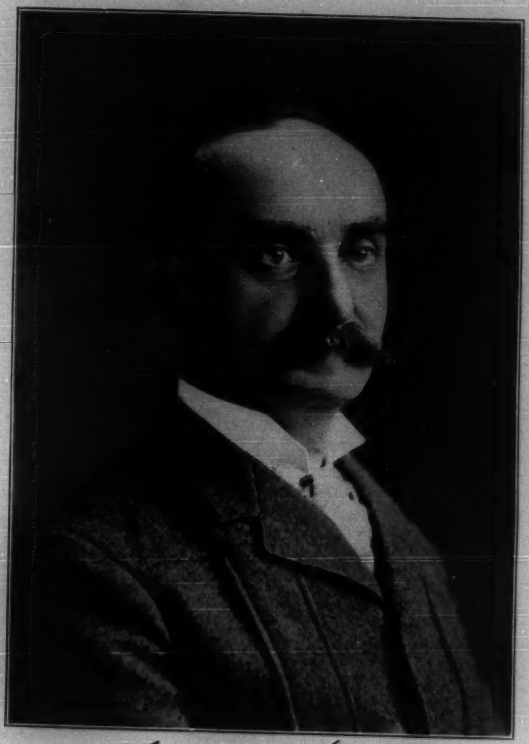
Cassius E. Gillette, Consulting Engineer, Philadelphia, Pa.

Geo. W. Sargent, Carpenter Steel Co., Reading, Pa.

Albert Sauveur, Cambridge, Mass.

Communications are also expected from the Professors and Lecturers of the Official Staff of Instruction of the Institute.



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